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BIBLIOGRAPHICAL HISTORY
OF
ELECTRICITY & MAGNETISM

St. Augustine. "La Cité de Dieu."
from a manuscript in the Musée de Chantilly.

BIBLIOGRAPHICAL HISTORY
OF
ELECTRICITY & MAGNETISM

CHRONOLOGICALLY ARRANGED

RESEARCHES INTO THE DOMAIN OF THE EARLY SCIENCES, ESPECIALLY FROM THE PERIOD OF THE REVIVAL OF SCHOLASTICISM, WITH BIOGRAPHICAL AND OTHER ACCOUNTS OF THE MOST DISTINGUISHED NATURAL PHILOSOPHERS THROUGHOUT THE MIDDLE AGES

COMPILED BY

PAUL FLEURY MOTTELAY, Ph.D.

AUTHOR OF
"GILBERT OF COLCHESTER," "THE BIBLIOGRAPHY OF ELECTRO-CHEMISTRY," ETC.

WITH INTRODUCTION BY THE LATE

PROF. SILVANUS P. THOMPSON, D.Sc., F.R.S.

AND FOREWORD BY

SIR R. T. GLAZEBROOK, K.C.B., D.Sc., F.R.S.

"Historia, quoquo modo scripta delectat."—*Pliny.*
"Felix qui potuit rerum cognoscere causas."—*Virgil.*
"Il importe beaucoup de connaître l'histoire de la science à laquelle on s'attache."—*Éloge de Boerhaave.*
"It is of great advantage to the student of any subject to read in the original memoirs on that subject, for science is always most completely assimilated when it is found in its nascent state. Every student of science should, in fact, be an antiquary in his subject."—*J. Clerk Maxwell.*
"Les tâtonnements de nos prédécesseurs nous apprennent à marcher avec plus de sûreté, et l'on ne sait jamais mieux conduire la science en avant que lorsqu'on sait le chemin qu'elle a parcouru jusqu'à nous."—*J. P. Rossignol.*

WITH FRONTISPIECE AND PLATES

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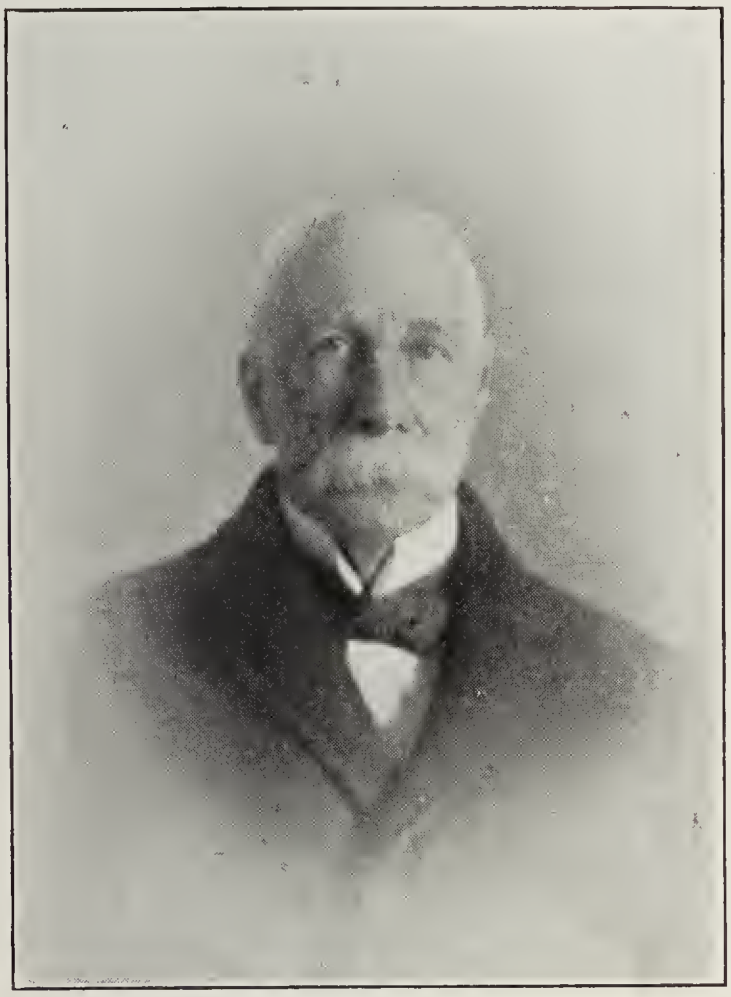

PORTRAIT OF

THE AUTHOR

TAKEN FOR
A PASSPORT TO FRANCE
A FEW WEEKS
BEFORE HIS DEATH

FOREWORD

BY

SIR RICHARD T. GLAZEBROOK, K.C.B., D.Sc., F.R.S.

Past President of the Institute of Electrical Engineers
and late Director of the National Physical Laboratory

THIS splendid volume has a tragic story. Dedicated to Lord Kelvin, it opens with an introduction by Silvanus Thompson and a preface by the distinguished author who himself passed from us before the book containing the fruit of many years of toil was ready for issue.

And what toil! A Bibliographical History of Electricity and Magnetism covering 4458 years, from 2637 B.C., when Hoang-Ti, Emperor of China, is said to have directed the pursuit of his troops after a rebellious subject by the aid of the compass, up to Christmas Day, A.D. 1821, when Faraday first caused a wire carrying a current to rotate in a magnetic field.

The early centuries are passed over quickly. Homer's name occurs with quotations from the *Odyssey*:

> "In wondrous ships self-mov'd, instinct with mind,
> No helm secures their course, no pilot guides;
> Like men intelligent, they plough the tides."

Does this mean that the Greeks knew of the compass? The author is doubtful.

To follow Title.]

FOREWORD

Thales, 600–580 B.C., the discoverer of frictional electricity, follows. The Crusaders wrote of the magnet. A facsimile page is given of Vincent de Beauvais' *Speculum Naturale*, and Gauthier d'Espinois, who lived about A.D. 1250, sang to his mistress:

> "Tout autresi (ainsi) comme l'aimant deçoit (detourne)
> L'aigulette pas force de vertu
> A ma dame tot le mont (monde) retennue
> Qui sa beauté connoit et aperçoit."

And when one passes to more recent years, there is not a name one knows omitted from the list. There are also many included who all contributed in some way to the growth of natural knowledge, but who can only be known to the few, the very few, who have burrowed in past records scattered far and wide with the perseverance, the patience, and the skill of Dr. Mottelay.

And he has discovered interesting facts without number, and at the same time has supported his case with full references to original works. To the question, How can I find out what—some unknown writer—has written about Electricity? there can in future be but one answer: Look him up in Dr. Mottelay's *Bibliographical History*. Our debt to the author is no small one; our regrets that he is not here to be gratified by the reception his book must meet with are deep and sincere.

The Great War delayed the issue of the book. The public are indebted to Messrs. C. Griffin & Co., Ltd., for bringing out a work of the kind under the difficulties which all scientific publications have met with since 1918, and Dr. Mottelay realized to the full the value of the assistance they gave him. I trust with confidence that electricians throughout the world (for the interest of the book is world-wide) will not be slow to show their appreciation of the work of all those who have combined to render them so marked a service.

R. T. GLAZEBROOK.

TO

THE REVERED MEMORY

OF

LORD KELVIN

PREFACE

The present work is the definitive edition of my " Chronological History of Magnetism, Electricity and the Telegraph," which had tentative publication (1891–1892) serially in four leading technological Journals, viz. " Engineering " of London, " The Electrical World " of New York, " La Lumière Electrique " of Paris, and " L'Industrie Moderne " of Brussels.

Since the time of that first publication, it has received a most thorough revision of the original text, for correction of faults of form, or of substance, suggested by learned critics conversant with the history of electricity and magnetism; and there have been added a very large number of new entries besides exhaustive notices of the work done by Peregrinus, Gilbert, Oersted, Faraday and other great pathfinders, also biographical and bibliographical notices of all the prominent ancient writers mentioned in the original compilation.

This bibliography commences B.C. 2637—conclusively shown to be the earliest date at which history notes anything resembling the application of the magnetic influence—and it ends with Michael Faraday, esteemed by Tyndall to be " the greatest experimental philosopher the world has ever seen," and who is held " to have done more for the development of electrical science than any other investigator." Thus is the chronological series shown to cover 4458 years, being purposely made to terminate at A.D. 1820–1821 (Oersted, Ampère, Arago, Faraday, etc.), the culminating period when, through the splendid discovery of electromagnetism, the two immense groups of phenomena were first linked together.

Besides the matter distinctly involved in the title of the new work, it has been deemed advisable to note in this History all the most important forms of the optical telegraph, or semeiograph. Many of the ancient and historical methods for communicating intelligence swiftly at great distances are noticed in their chronological order : doubtless, this will prove to the generality of readers no less interesting than the vast multitude of curious facts pertaining to the direct line of researches. An exhaustive cross-entry Index

of Selected Names and Subjects, embracing fuller titles and much additional data that could not well be entered into the body of the work, will, for the first time, make this mass of historical data readily accessible.

To bar controversies and partisan discussion as to the relative merits of different discoverers and inventors, concerning which authorities are at variance, it has been thought best to quote all of the weightiest known authorities under the respective heads and dates of the several claimants. To the would-be historian and to the delving student, this will certainly appear the better course. A case in point, and it is no uncommon one, attaches to the invention of the mariner's compass, where that instrument and its original employment in navigation are credited with equal assurance to China, Iceland, France, England and Italy, by equally eminent historians and scientists. And, as nearly all, except the very earliest, discoveries of any high importance have already been traced to their respective origins by many authors, additional data have been gathered and quoted wherever such data seemed deserving of more than the ordinary notices previously accorded them in print, or where the peculiar nature of the discovery, or the identity of its author, merited authentication to preclude doubt or controversy.

The unusual number of cumulative references purposely given throughout many entries (the most important of which were originally set in italics) cannot be seriously objected to, as they afford ready means for making searches through different accessible channels, covering various phases of a subject, and they facilitate the verification of all extracts and of all quoted passages. They likewise effectually offset the likelihood of misprints necessarily attaching to many of the authorities which are cited from, and which often can be found solely in, rare early publications or in more or less unintelligible manuscripts. Only those who have had to make important searches through such can appreciate the difficulties which continually beset the investigator. Many of the older serials likewise prove quite unreliable and disappointing, either through wrong pagination or irregular and sometimes conflicting dates of publication, as well as through the rearrangement or redistribution of parts or series, at various periods and in different volumes. This is the case, more particularly, with "Le Journal des Savants" and with "The Philosophical Transactions," as it is also with many technical serial publications of various countries which are referred to in the following pages.

In the Preface to his "Experimental Researches," the great

Faraday justly remarked that: "The date of a scientific paper containing any pretensions to discovery is frequently a matter of serious importance, and it is a great misfortune that there are many most valuable communications, essential to the history and progress of science, with respect to which this point cannot now be ascertained. This arises from the circumstance of the papers having no dates attached to them individually, and of the Journals in which they appear having such as are inaccurate, *i. e.* dates of a period earlier than that of publication."

Of the aforenamed serials, the very important "Philosophical Transactions" have doubtless been most frequently alluded to herein, both in their original and abridged forms, and, for that reason, the assistance of representatives of the Royal Society has been sought in order to give a proper account to date, showing the difficulties which have throughout been encountered by its many successive editors. It will be seen, at pages 546–547, that there were numerous irregularities in the publication of the unabridged series from the initial date of 1665, only seven numbers having been issued from 1679 to 1682, whilst neither numbers nor volumes appeared between 1688 and 1690, and that, through lax editing, various numbers were often, during subsequent years, assigned to volumes differently designated. In the many abridged reports, irregularities are still greater, as shown at pages 547–548. During 1721, Motte edited "an abridgment, 1700–1720, in three volumes which was very incorrect" ("Dict. Nat. Biog.," Vol. XXXIX. p. 194). The six volumes of 1720–1732 also appeared in two volumes, published 1733. The two volumes of 1719–1733 contained an "Index to the previous seven volumes" by different authors. This was made up by John Martyn, who published in five volumes an abridgment of the Transactions for 1719–1750, which he had previously issued in three sets of two volumes each. Mr. Samuel H. Scudder's remarks as to various discrepancies are worthy of notice. He says ("Cat. of Scient. Serials," 1879, p. 27) that "the Philosophical Transactions Abridged have been very irregularly issued. The first five volumes went through several editions (from five to two, according to the volume) between 1705 and 1781; the later volumes through only one, 1734–1756." He adds: "There is a strange discrepancy here, the fourth edition of the first volume being sometimes dated 1731, sometimes 1781, and sometimes 1782, whilst the fifth edition of volumes one to three is dated 1749; the eighth volume is again sometimes dated 1734, sometimes 1747."

Were I to indite an *apologia* for the present work, I could not

hope to express it more happily than does Mr. J. J. Fahie in the preface to his "History of Wireless Telegraphy, 1838–1899"; or, I might adopt the words of two of the most learned French authors of the day:

"Si je donne ces détails, nouveaux, ou peu connus, c'est qu'il est toujours intéressant de remonter à l'origine et au développement successif des inventions." (M. Berthelot, in the "Comptes Rendus.")

"S'il n'y a pas beaucoup de gens qu'elles intéressent, il y en a qu'elles intéressent beaucoup. À ceux-ci, nous avons, en rédigeant ces notes, eu l'intention et l'espérance de venir quelquefois en aide. Tout catalogue a des points obscurs, même les meilleurs. . . . L'office propre, le devoir de la critique, est de rechercher si ces points obscurs ne pourraient pas être éclairés par quelque lumière. Il est vrai qu'elle y perd souvent sa peine. Mais cela ne doît jamais la décourager." (M. Hauréau, in "Le Journal des Savants.")

I am especially thankful for the warm encouragement which I have received, on all sides, since the original work appeared in serial form. This History has been frequently called for, and I regret that I have been hitherto prevented from bringing it out earlier in its present desirable book form. This is the more to be regretted as it long ago received the practical endorsement of the *doyen* of the electrical profession, Lord Kelvin (formerly styled Sir William Thomson), to whom it is dedicated. Leave to do this was obtained through a mutual friend in such a cordial manner that I cannot refrain from giving the correspondence attaching thereto:

Westminster Chambers,
London, S.W.,
January 4, 1894.

"Dear Mottelay,

"I duly received yours of the 21st . . . but the point on which I feel guilty is your *dedication*. . . . I have now started the matter by writing to Lord Kelvin fully on the subject, and I hope, within a week, to get his reply, which I shall at once send to you—he cannot possibly wish to decline the honour. . . .

"I remain,
"Yours very truly,
"Latimer Clark."

Westminster Chambers,
London, S.W.,
January 13, 1894.

"Dear Mottelay,

"Lord Kelvin's letter is so nice a one that I send you the original, otherwise I should have liked it as an autograph for my library. I shall be glad to hear that it has duly reached you. . . .

"Yours very truly,
"Latimer Clark."

The University,
Glasgow,
January 11, 1894.

"Dear Clark,

"Your letter of the 4th should have been answered sooner, but for my absence from home at the time it came.

"Will you tell Mr. Mottelay that I shall feel honoured by his dedicating his "Chronological History of Electricity and Magnetism" to me, and express to him my thanks for his kind proposal to do so.

"Yours very truly,
"Kelvin."

I desire to record my great indebtedness to Dr. Silvanus P. Thompson, D.Sc., F.R.S., for the interest he has throughout manifested in, and the material aid he has given to, the improvement and development of the present work. Especial acknowledgment is made of Dr. Thompson's personal revision of the articles on Petrus Peregrinus (at A.D. 1269), on William Gilbert (at A.D. 1600), and on Michael Faraday (at A.D. 1821). With all of these authors, he has become very prominently identified through the several special publications concerning them, which have been issued by him at different periods, and all of which are herein noticed in their proper order.

Thanks are likewise due, and are also by me hereby tendered, more particularly to Dr. Elihu Thomson, of the Massachusetts Institute of Technology; to Dr. J. A. Fleming, M.A., F.R.S.; to Mr. W. D. Weaver, late Editor of the "Electrical World"; to Mr. Wm. J. Hammer, representative of Mr. Thomas A. Edison; to Mr. A. Hastings White, assistant-librarian, Royal Society, London; to Messrs. Charles Spon and Louis H. Walter, M.A.; to Messieurs Henri Omont, Bibliothèque Nationale; Paul Marais, Bibliothèque Mazarine; Henri Martin, Bibliothèque de l'Arsenal;

Amédée Boinet, Bibliothèque Ste. Geneviève; Messieurs Plon Nourrit et Cie; as well as to Professors C. F. Brackett, William Hallock and Edward L. Nichols, of the Universities of Princeton, Columbia and Cornell; also to Sir Arthur Schuster, Sir Edwin Durning-Lawrence, Dr. Robert L. Mond, and Dr. Horace F. Parshall, for many valuable suggestions and other aid given by all of them at different periods to the material benefit of this compilation.

It is scarcely necessary adding that, notwithstanding the great care given to the preparation of this very extensive Bibliography, and to its difficult "proof" reading, errors will undoubtedly present themselves. It is, however, hoped these will not prove of material importance. Such mistakes as are of a typographical nature can easily be recognized and in due time remedied; those, however, resulting from the conflict of authorities are more difficult to trace, and I shall greatly appreciate their being pointed out to me, with the view to improving future editions.

P. Fleury Mottelay.

INTRODUCTION

Anyone who enters on the perilous paths of Bibliography realizes, sooner or later, the truth that "of the making of books there is no end." But there was a beginning: and if the Bibliography of Electricity promises to stretch onward into the future in endless line, at least its backward reach might seem to be finite in date. Nevertheless, the student of the early periods of book production, when the science of electricity was literally in that "infancy" from which in our time it has emerged, is continually finding that there are early works of which he was unaware, and of which even our best libraries are destitute. He finds, as he progresses backward, toward the origins of things, in how many points our ancestors in the domain of electric science had anticipated the discoveries of later date. He finds that, again and again, by some rare stroke of insight, the great minds that had devoted themselves to the research of phenomena had seen—it may be, with dim or imperfect glimpses—many of the things which are commonly regarded as quite modern. The pioneer, unbiased by the views of contemporary philosophers, unhampered by the load of textbook tradition, often sees further than the professed researcher who comes after him.

The art of scientific discovery—for it is an art—can be attained in but one way, the way of attainment in all arts, namely, by practising it. In the practice of art, the aspirant may at least learn something that all the textbooks cannot drill out of him, and which will help him in his practice, by the careful examination of the actual ways in which the discoveries of science, now facts of history, were actually made. But, to do this, he must throw overboard for a time the systematic textbooks, he must abandon the logical expositions which embody, at second hand, or at third hand, the antecedent discoveries, and he must go to the original sources, the writings and records of the discoverers themselves, and learn from them how they set to work. The modern compendious handbooks in which the results of hundreds of workers have been boiled down, as it were, to a uniform consistency, is exactly the intellectual pabulum which he must eschew. Let him read Faraday, not through the eyes of Maxwell or of Tyndall, but in his own words in the immortal pages of the "Experimental Researches," with their wealth of petty detail

and their apparent vagueness of speculation. Let him read Ohm's own account of the law of the circuit, not some modern watered-down version. Let him turn over the pages of Franklin's letters to Collinson, as his observations dropped red-hot out of the crucible of his endeavours. Let him read Stephen Gray's charming experiments in the old-world diction that befitted a pensioner of the Charter-house. Let him go back to old Gilbert, who had talked with Drake and Sir Walter Raleigh in the flesh, who had discussed magnetism with Fra Paolo Sarpi and had experimented on the dip of the needle with Robert Norman. Gilbert's account of his own experiments is for the would-be scientific discoverer worth a hundredfold the Novum Organon of the overpraised Francis Bacon. Nay, let him go back to Peter Peregrinus, the soldier-pioneer, and see how he experimented with floating lodestones before he penned his account of the pivoted magnet—the earliest known instrument that can rightly be called a mariner's compass. Not until he has thus become a bit of an antiquary will be have fully understood how the discoveries of old were made. And, in precisely the same spirit of quest, though with the wealth of modern appliances at his command, must he go to work, if new discoveries are to be made by him.

But, for all this, he needs a guide to tell him what are the records of the original pioneers, by what names their works are called, and where they can be found. Such a guide doubtless exists to some extent in the mere catalogues of electrical literature, such as the catalogue of the Ronalds' Library at the Institution of Electrical Engineers, in London; or, more fully, even, in the new Catalogue of the Latimer Clark Library, now known as the Wheeler Collection, at the American Institute of Electrical Engineers, in New York. The Chronological History of Electricity which Mr. P. F. Mottelay contributed, week by week, to the columns of the " Electrical World " and of " Engineering " in the years 1891–1892, was the beginning of an attempt to provide an even more complete analysis of the earlier literature of the subject. But these are only the beginnings.

In the " Bibliographical History of Electricity and Magnetism," which Mr. Mottelay is now giving to the world, a far more exhaustive and detailed account is rendered of the earlier workers and writers in our dual science. He has particularly worked up all important electrical channels, and in the more extended articles, some of which it has been the writer's privilege to peruse in advance, there are presented valuable monographs dealing with particular workers who each in his own day made notable contributions to the advance of the science.

To all who would tread in their paths, and add something to the

ever-widening domain of electrical discovery, this Bibliographical History may be commended, not only for what it contains, but for the appreciative spirit in which it brings before the reader the work of those men who made the science what it is.

Pioneers; O Pioneers!

Silvanus P. Thompson.

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THE BIBLIOGRAPHICAL HISTORY OF ELECTRICITY AND MAGNETISM

FROM B.C. 2637 TO A.D. 1821

B.C. 2637.—This date has been conclusively shown to be the earliest one at which history notes anything resembling the application of the magnetic influence. It is related that, during this sixty-first year of the reign of Hoang-ti (Yeou-hioung-che, also named Koung-fun and Hiuen-yuen), the emperor's troops, who were pursuing the rebellious prince Tchéyeou (Tchi-yeou), lost their way, as well as the course of the wind, and likewise the sight of their enemy, during the heavy fogs prevailing in the plains of Tchou-lou. Seeing which, Hoang-ti constructed a chariot upon which stood erect a prominent female figure which indicated the four cardinal points, and which always turned to the south whatever might be the direction taken by the chariot. Thus he succeeded in capturing the rebellious prince, who was put to death.

Some say that upon this chariot stood a needle, to denote the four parts of the world. That, states the French author writing in 1736, would "indicate the use of the compass, or something very similar to it . . . and it is unfortunate that the device has not been explained more fully."

REFERENCES.—Du Halde, "Description de la Chine . . .," La Haye, 1736, Vol. I. pp. 270–271; B.C. 2634, Klaproth, "Boussole," pp. 33, 34, 71, 74, 76, 79, 82; Azuni, "Boussole," Paris, 1809, pp. 186, 214; Staunton's "China," London, 1797, Vol. I. p. 446; "Encycl. Metrop.," Vol. III. p. 736; Buffon, "La Terre," Vol. I. p. 304; Davis, "The Chinese," 1844, Vol. III. p. 14; Humboldt, "Cosmos," 1848, Vol. V. p. 51, for Ed. Biot in *Comptes Rendus*, Vol. XIX. 1844, p. 822; Dr. A. T. Thompson, translation of Salverte's "Philosophy of Magic," 1847, Vol. II. chap. xi. p. 222 (note), wherein he alludes to Davies' "Early History of the Mariner's Compass"; "British Annual," 1837; Saillant et Nyon, "Mémoires concernant l'Histoire," Paris, 1788, Vol. XIII. pp. 234–235, giving chronological tables of the history of China, also p. 227 relative to Hoang-ti; P. Etienne Souciet, "Observations," Paris, 1732, Vol. II. pp. 94–95.

Hoang-ti (Hoang, supreme king), third in the "Period of the Five Emperors" (Claude Augé, "Nouveau Larousse," Vol. V. p. 134), regarded as the founder of the Chinese Empire, died at the age of 121, after reigning 100 years, B.C. 2598. Mailla (Joseph

A. M. de Moyriac de) in his "Histoire . . . traduite du Thoung-Kian-Kang-Mou," Paris, 1777, Vol. I. p. 28, makes the latter date 2599, as do likewise, Dr. Hœfer ("Nouvelle Biographie Générale," Paris, 1858, Vol. XXIV. pp. 817–819) and Pierre Larousse ("Grand Dict. du XIX^e Siècle," 1873, Vol. IX. p. 317), but Michaud ("Biogr. Univer.," 1857, Vol. XIX. pp. 476–477) says he reigned from 2698 to 2577 B.C., and, in "La Grande Encyclop.," Vol. XX. pp. 157–158, we are told that the correct period is 2697–2597 B.C. ("L'art de vérifier les dates," Paris, 1819, Vol. IV. p. 8).

The above-named work of Jean Baptiste Du Halde on China is considered the most complete account of that vast empire that has appeared in Europe ("New Gen. Biogr. Dict.," London, 1850, Vol. VIII. p. 175). In any case, remarks Mr. Demetrius C. Boulger ("History of China," London, 1881, Vol. I. pp. 4–5), it is incontestable that the individuality of Hoang-ti, who was the successor of "Fo-hi," the first great Chinese emperor, is much more tangible than that of any of his predecessors.[1] By him, it is well recorded that the extensive Chinese territory (Empire) was divided into ten provinces, or *Chow*, each of which was subdivided into ten departments, or *Tsee*, and these again into ten districts, or *Tou*, each of them containing ten towns, or *Ye*.

[1] Touching the antiquity of the Chinese nation, the distinguished French author, J. P. Pauthier ("Chine," Paris, 1839, pp. 20, 27), thus expresses himself: "Son histoire authentique qu'elle fait remonter avec ce charactère de certitude, jusqu' à la 61^e année du règne de Hoang-ti, la première de leur premier cycle, 2637 ans avant notre ère. . . . Le cycle de 60 années dont les séries se suivent depuis la 61^e année du règne de Hoang-ti, sans interruption et avec autant de régularité que les siècles dans les computs Européens." And Saillant et Nyon ("Mémoires concernant l'histoire," Vol. XIII. p. 76) add conclusively: "Depuis l'année courante (1769) jusqu' à la 2637^e avant l'ère Chrétienne, qui répond exactement à la 61^e du règne de Hoang-ti, on peut sans crainte de s'égarer, suivre un des plus beaux sentiers de l'histoire, pendant l'espace de 4406 ans."

Incidentally, we may add that in his "History of Chaldea," New York, 1866, pp. 195, 213, 364, Mr. Z. A. Ragozin says that that country can point to a monumentally recorded date nearly 4000 B.C.—more than Egypt can do—and he says, furthermore, "we cannot possibly accept a date later than 4000 B.C. for the foreign immigration, and, for the Shumiro-Accadian culture, less than 1000 years, thus taking us as far back as 5000 B.C. The date of 3750 B.C. is that of Naram-Sin, and 3800 B.C. is now generally accepted for Sargon of Agadê—*perhaps the remotest authentic date yet arrived at in history.* To such as are inclined to doubt the authenticity of these early dates, as well as the truthfulness of "the mensuration of divine periods," and of "the observations of celestial bodies throughout the whole of time," it will be interesting to note the following, taken from the Greek "Iamblichus" translation of Thomas Taylor, Chiswick, 1821, p. 318: "Proclus (in *Tim.*, lib. iv. p. 277) informs us that the Chaldeans had observations of the stars which embraced whole mundane periods . . . likewise confirmed by Cicero, who says (in his first book on Divination) that they had records of the stars for the space of 370,000 years, and by Diodorus Siculus ('Bibl.,' lib. xi. p. 118), who states that their observations comprehended the space of 473,000 years!"

B.C. 1110.—Tcheou-Koung is said to have at this date taught the use of the needle compass to the envoys from Youa-tchang. "As the ambassadors sent from Cochin China and Tonquin" (Humboldt, "Cosmos," Vol. V. p. 51) "were about to take their departure" (which was in the twenty-second cycle, more than 1040 years B.C.), "Tcheou-Koung gave them an instrument which upon one side always turned toward the north and on the opposite side to the south, the better to direct them upon their homeward voyage.[1] This instrument was called *tchi-nan* (chariot of the south), and it is still the name given to the compass, which leads to the belief that Tcheou-Koung invented the latter." In his chapter on "The Magnetic Needle," Humboldt says the apparatus was called *fse-nan* (indicator of the south).

Tcheou-Koung (Ki-tan) was Chinese Minister of State under both Von-Vang (the first emperor of the Tcheou dynasty, who ruled seven years) and Tsching-Vang (second emperor, who ruled thirty-seven years), and lived to be 100 years old. He was one of the most learned and most popular men China has ever known, and is spoken of to this day by the Chinese "with an admiration bordering upon enthusiasm" (Saillant et Nyon, "Mémoires concernant l'Histoire," Paris, 1776, Vol. III. p. 37). The emperor Tsching-Vang caused Tcheou-Koung's body to be interred near his father's remains, after giving it imperial funeral honours.

REFERENCES.—Du Halde, "Description de la Chine . . .," La Haye, 1736, Vol. I. p. 312; Klaproth, "Boussole," p. 81; Azuni, "Boussole," pp. 190–191; Humboldt, "Cosmos," London, 1849, Vol. II. p. 628, and Vol. V. p. 52.

B.C. 1084.—According to Æschylus, the father of the Athenian drama, Agamemnon employed a line of optical signals to advise his queen Clytemnestra of the fall of Troy. Robert Browning's translation, London, 1877, runs as follows:

"Troia, the Achaioi hold. . . .
Hephaistos—sending a bright blaze from Idé
Beacon did beacon send, from fire the poster,
Hitherward: Idé to the rock Hermaian
Of Lemnos: and a third great torch o' the island
Zeus' seat received in turn, the Athoan summit.
And—so upsoaring as to stride sea over,
The strong lamp-voyager, and all for joyance—
Did the gold-glorious splendor, any sun like,
Pass on . . ."

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[1] "Le monument le plus ancien (de pierre scuptée) signalé par le King-che-so porte sur une façade cette scène d' histoire: 'Tcheou-Choung, régent de l'empire pendant la minorité de son neveu Tching-Ouang (1110 av. J. C.) reçoit les envois du roi des Yue-tchang-che. . . . Les anciens auteurs Chinois rapportent que ces ambassadeurs offrirent à la cour de Chine des éléphants et des faisans blancs et que pour leur retour Tcheou-Koung leur fit présent de chars qui montraient le sud.'" ("L'art Chinois," par M. Paléologue, Paris, 1888, pp. 132–134; J. P. Pauthier, "Chine," p. 87.)

Anna Swanwick thus renders Æschylus' "Agamemnon," London, 1881, p. 13:

> "For Priam's city have the Argives won.
> . . . .
> Hephaestos sending forth Idaian fire.
> Hither through swift relays of courier flame. . . ."

At page 193 of his "Agamemnon," London, 1873, E. H. Plumptre refers to the system of posts or messengers which the Persian kings seem to have been first to organize, and which impressed the minds of both the Hebrews (Esther viii. 14) and the Greeks (Herod., viii. 98) by their regular transmission of the king's edicts or of special news.

What of the passage from the celebrated patriarch Job (xxxviii. 35): "Canst thou send lightnings, that they may go, and say unto thee, 'Here we are?'" (original Hebrew, "Behold us"). As has been remarked, this seems prophetic, when taken in connection with the electric telegraph.

The fire beacons are also alluded to by Plutarch in his Life of Quintus Sertorius; and Mardonius prepared fire signals to notify Xerxes, then at Sardis, of the second taking of Athens.

References.—"Le Théatre des Grecs," P. Brumoy, Paris, 1820, Vol. II. pp. 124–125; "Penny Encyc.," Vol. XXIV. p. 145; Knight's "Mechan. Dict.," Vol. III. p. 2092.

For a decidedly original explanation of the beacon fires, read the introduction to "The Agamemnon of Æschylus," translated by A. W. Verrall, Fellow of Trinity College, Cambridge, England. See, likewise, reference to Act of Scottish Parliament, 1455, c. 48, made by Walter Scott in a note to his "Lay of the Last Minstrel"; "Archeologia," London, 1770, Vol. I. pp. i–7.

B.C. 1068.—In the obscure age of Codrus, the seventeenth and last king of Athens, at about the period of the "Return of the Heraclidae" (descendants of Heracles—Hercules) to the Peloponnesus, the Chinese had magnetic carriages, upon which the movable arm of the figure of a man continually pointed to the south, and which it is said served as a guide by which to find the way across the boundless grass plains of Tartary. Humboldt states, besides, that, even in the third century of our era, Chinese vessels navigated the Indian Ocean under the direction of magnetic needles pointing to the south, and that, at pages xxxviii–xlii, Vol. I. of his "Asie Centrale," he has shown what advantages this means of topographical direction, as well as the early knowledge and application of the magnetic needle, gave the Chinese geographers over the Greeks and Romans, to whom, for instance, even the true direction of the Pyrenees and the Apennines always remained unknown.

References.—Humboldt, "Cosmos," London, 1849, Vol. I. p. 173, also his "Examen Critique de l'histoire de la Géographie," Vol. III.

p. 36; "Mœurs de Reg. Athen.," lib. iii. cap. xi. For Codrus and the Heraclidæ, consult: Chambers' "Encycl.," 1889, Vol. III. p. 329 and Vol. V. 1890, p. 657; "Encycl. Britan.," 9th ed., Edinburgh, Vol. VI. p. 107 and Vol. XI. p. 92; Hœfer, "Nouv. Biog. Gén.," Vol. XI. p. 29.

B.C. 1033–975.—Solomon, King of Israel, son of King David and of Bathsheba, who, "in the Jewish scriptures, has the first place assigned to him among the wise men of the East," is believed by many to have known the use of the compass. The Spanish Jesuit Pineda and Athanasius Kircher assert the same, and state that Solomon's subjects employed it in their navigations. Others, notably Fuller, "Miscel.," iv. cap. 19, and Levinus Lemnius, "De Occulta Naturae Miracula," lib. iii, have even tried to prove that Solomon was the inventor of the compass, and that it was in his time used by the Syrians, Sidonians and Phœnicians, but the contrary has been shown by Henricus Kippingius in his "Antiq. Rom. de exped. Mar.," lib. iii. cap. 6, as well as by Bochart, the geographer, in his "Géo. Sacr.," lib. i. cap. 38.

References.—Venanson, "Boussole," Naples, 1808, p. 34; Enfield, "History of Philosophy," London, 1819, Vol. I. p. 40; Cavallo, "Magnetism," 1787, p. 48; Ronalds' "Catal.," 1880, articles "Hirt" and "Michaelis," pp. 246, 344.

B.C. 1022.—At this period the Chinese magnetic cars held a floating needle, the motions of which were communicated to the figure of a spirit whose outstretched hand always indicated the south. An account of these cars is given in the "Szuki" (Shi-ki), or "Historical Memoirs of Szu-ma-thsian" (Szu-matsien), which were written early in the second century B.C., and are justly considered the greatest of all Chinese historical works, containing, as they do, the history of China from the beginning of the empire to the reign of Hiao-wou-ti, of the Han dynasty.

References.—"Les peuples Orientaux," Léon de Rosny, Paris, 1886, pp. 10, 168, 240; Johnson's "Encyclopædia," Vol. I. p. 929; Humboldt, "Cosmos," Vol. II. 1849, p. 628; Klaproth, "Boussole," 1834, p. 79, for further allusion to a passage in the Thoung-Kian-Kang-Mou, already referred to under date B.C. 2637.

B.C. 1000–907.—Homer, the greatest of epic poets, called the father of Greek poetry, and who, according to Enfield ("History of Philosophy," Vol. I. p. 133), flourished before any other poet whose writings are extant, relates that the loadstone was used by the Greeks to direct navigation at the time of the siege of Troy.

The latter construction has been placed upon several passages in Homer, the most important being found in Book VIII of the "Odyssey."

As this appears to be the first attributed allusion to the compass, it is deemed worth while to give herein several interpretations of the original Greek. The selections made are as follows:

"In wond'rous ships, self-mov'd, instinct with mind;
No helm secures their course, no pilot guides;
Like man intelligent, they plough the tides,
. . . .
Though clouds and darkness veil th' encumber'd sky,
Fearless thro' darkness and thro' clouds they fly."
Alexander Pope, "The Odyssey of Homer," London, 1818, p. 135.

". . . ; for here
In our Phæacian ships no pilots are,
Nor rudders, as in ships of other lands.
Ours know the thoughts and the intents of men.
To them all cities and all fertile coasts
Inhabited by men are known; they cross
The great sea scudding fast, involved in mist
And darkness, with no fear of perishing
Or meeting harm."
Wm. Cullen Bryant, "The Odyssey of Homer," Boston, 1875, Vol. I. p. 174.

"For unto us no pilots appertain,
Rudder nor helm which other barks obey.
These ruled by reason, their own course essay
Sparing men's mind . . .
Sail in a fearless scorn of scathe or overthrow."
Philip Stanhope Worsley, "The Odyssey of Homer," London, 1861, Vol. I. p. 198.

"For all unlike the ships of other men,
Nor helm nor steersman have our country's barks,
But of themselves they know the thoughts of men;
. . . and wrapped in gloom and mist
O'er the broad ocean gulfs they hold their course
Fearless of loss and shipwreck . . ."
Earl of Carnarvon, "The Odyssey of Homer," London, 1886, p. 201.

"These marvellous ships, endued with human sense, and anticipating the will of their masters, flit unseen over the sea."—"Homer's Odyssey," by W. W. Merry and James Riddell, Oxford, 1886, Vol. I. p. 353, note.

"That our ships in their minds may know it when they bring thee hither to hand,
Because amidst us Phæacians, our ships no helmsmen steer,
Nor with us is any rudder like other ships must bear,
But our keels know the minds of menfolk, and their will they understand,
. . . .
And therewith exceeding swiftly over the sea-gulf do they go,
In the mist and the cloud-rack hidden . . ."
"The Odyssey of Homer," translated by Wm. Morris, London, 1887, p. 145.

The afore-named construction is not, however, alluded to by Matthew Arnold in his well-known lectures given at Oxford, nor by the Right Hon. Wm. Ewart Gladstone either in his "Juventus Mundi" or throughout his very extensive "Studies on Homer and the Homeric Age."

Sonnini tells us that as this period is about the same as that of the Chinese chronicles, it can scarcely be doubted that the knowledge of both the polarity of the needle and of the use of the compass

for navigation date back 3000 years (Buffon, "Terre," Paris, An. VIII. p. 304).

This ill accords, however, with the views of others who have concluded, perhaps rightly, that the Greeks, Romans, Tuscans and Phœnicians[1] were ignorant of the directive property of the magnet, from the fact that none of the writings, more especially of Theophrastus, Plato, Aristotle, Lucretius and Pliny, make explicit allusion thereto.

References.—Humboldt, "Cosmos," 1859, Vol. V. p. 51; "Good Words," 1874, p. 70; Brumoy, "Théâtre des Grecs," 1820, Vol. I. p. 55; Pope's translation of the "Iliad," 1738, Vol. I. pp. 14, 20; Schaffner, "Telegraph Manual," p. 19; also references under both the A.D. 121 and the A.D. 265–419 dates.

B.C. 600–580.—Thales of Miletus, Ionia, one of the "seven wise men of Greece" (the others being Solon, Chilo, Pittacus, Bias, Cleobolus and Periander), founder of the Ionic philosophy, and from whose school came Socrates, is said to have been the first to observe the electricity developed by friction in amber.

Thales, Theophrastus, Solinus, Priscian and Pliny, as well as other writers, Greek and Roman, mention the fact that when a vivifying heat is applied to amber it will attract straws, dried leaves, and other light bodies in the same way that a magnet attracts iron ("Photii Bibliotheca" Rothomagi, 1653, folio, col. 1040–1041, cod. 242).

Robert Boyle ("Philosophical Works," London, 1738, Vol. I. p. 506, or London, 1744, Vol. III. p. 647) treats of different hypotheses advanced to solve the phenomena of electrical attraction, saying: "The first is that of the learned Nicholas Cabaeus (A.D. 1629), who thinks the drawing of light bodies by amber . . . is caused by the steams which issue out of such bodies and discuss and expel the neighbouring air . . . making small whirlwind. . . . Another is that of the eminent English philosopher, Sir Kenelm Digby (A.D. 1644), and embraced by the very learned Dr. Browne (A.D. 1646) and others, who believed that . . . chafed amber is made to emit certain rays of unctuous steams, which, when they come to be a little cooled by the external air, are somewhat condensed . . . carrying back with them those light bodies to which they happen to adhere at the time of their retraction. . . . Pierre Gassendi (A.D. 1632) thinks the same, and adds that these electrical rays . . . get into the pores of a straw . . . and by means of their decussation take the faster hold of it . . . when they shrink back

[1] While the Greeks steered by the Great Bear, which, if a more visible, was a far more uncertain guide, the Phœnicians had, at an early time, discovered a less conspicuous but more trustworthy guide in the polar star, which the Greeks call *The Phœnician Star* ("History of Antiquity," Prof. Max Duncker, translated by Evelyn Abbott, London, 1882, Vol. II. p. 293).

to the amber whence they were emitted . . . Cartesius (Descartes, A.D. 1644) accounts for electrical attractions by the intervention of certain particles, shaped almost like small pieces of riband, which he supposes to be formed of this subtile matter harboured in the pores or crevices of glass."

The ancients were acquainted with but two electrical bodies—amber (*electron*), which has given the denomination of the science; and *lyncurium*, which is either the tourmaline or the topaz (Dr. Davy, "Mem. Sir Humphry Davy," 1836, Vol. I. p. 309). From a recent article treating of gems, the following is extracted: "The name of the precious stone inserted in the ring of Gyges has not been handed down to us, but it is probable that it was the topaz, whose wonders Philostratus recounts in the Life of Apollonius. An attribute of the sun and of fire, the ancients called it the *gold magnet*, as it was credited with the power of attracting that metal, indicating its veins, and discovering treasures. Heliodorus, in his story of Theagenes and Caricles, says that the topaz saves from fire all those who wear it, and that Caricles was preserved by a topaz from the fiery vengeance of Arsaces, Queen of Ethiopia. This stone was one of the first talismans that Theagenes possessed in Egypt. The topaz, at present, symbolizes Christian virtues—faith, justice, temperance, gentleness, clemency."

REFERENCES.—"Greek Thinkers," by Theodor Gomperz, translation of L. Magnus, London 1901, p. 532; Zahn at A.D. 1696; Joannes Ruellius, "De Natura Stirpium," 1536, p. 125; Paul Tannery, "Pour l'Histoire de la Science Hellène," Paris, 1887, chap. iii. pp. 52–80; Becquerel, "Traité Expérimental," Paris, 1834, Vol. I. p. 33; Pliny, "Natural History," Bostock and Riley, 1858, book 37, chap. xii. p. 403; Pline, "Histoire Naturelle," 1778, livre 37, chapitre iii.; Lardner, "Lectures," 1859, Vol. I. p. 104; Humboldt, "Cosmos," 1849, Vol. I. p. 182; Poggendorff, XI. p. 1088; Apuleius, Floridor, p. 361; Plato; Timæus, The Locrian; "De Anima Mundi . . .," 12, 15; Pauli (Adrian), Dantzig, 1614; Ulysses Aldrovandus, "Musaeum Metallicum," pp. 411–412; Aurifabrum (Andreas), "Succini Historia," . . . Königsberg, 1551–1561; and, for the different names given to amber and the magnet by the ancients, consult, more especially, the numerous authorities cited by M. Th. Henri Martin ("Mém. présenté à l'Académie des Inscrip. et Belles Lettres," première partie, Vol. VI. pp. 297–329, 391–411, Paris, 1860); J. Matthias Gessner, "De Electro Veterum" (Com. Soc. Reg. Sc. Gött., Vol. III for 1753, p. 67); Louis Delaunay, "Minér. des Anciens," Part 2, p. 125 (Poggendorff, Vol. II. p. 540); Philip Jacob Hartmann, in *Phil. Trans.*, Vol. XXI. No. 248, pp. 5, 49, also in Baddam's Abridgments, Vol. III, first edition, 1739, pp. 322–366.

B.C. 600.—The Etruscans are known to have devoted themselves at this period to the study of electricity in an especial manner.[1]

[1] The Etruscans "inquired, under the direction of technical rules, into the hidden properties of nature, particularly those of the electric phenomena." "History of the Romans," by Chas. Merivale, New York, 1880, Vol. II. p. 395. (Cicero, "De Divin.," i. 41–42; Diod. Sic., v. 40; Senec., "Nat. Qu.," ii. 32; Micali, "l' Italie," ii. 246 foll.).

They are said to have attracted lightning by shooting arrows of metal into clouds which threatened thunder. Pliny even asserts that they had a secret method of not only "drawing it (the lightning) down" from the clouds, but of afterwards "turning it aside" in any desired direction. They recognized different sources of lightning, those coming from the sky (*a sideribus venientia*), which always struck obliquely, and others from the earth (*infera, terrena*), which rose perpendicularly. The Romans, on the other hand, recognized only two sorts, those of the day, attributed to Jupiter, and those of the night, attributed to Summanus (see Vassalli-Eandi at A.D. 1790).

This Vassalli-Eandi—like L. Fromondi—made special study of the very extensive scientific knowledge displayed by the ancients and, as shown in his "Conghietture . . ." he concluded that they really possessed the secret of attracting and directing lightning. The above-named extracts concerning the Etruscans and Romans are made from the subjoined work of Mme. Blavatsky, wherein the following is likewise given.

Tradition says that Numa Pompilius, the second king of Rome, was initiated by the priests of the Etruscan divinities, and instructed by them in the secret of forcing Jupiter, the Thunderer, to descend upon earth. Salverte believes that before Franklin discovered his refined electricity, Numa had experimented with it most successfully, and that Tullus Hostilius, the successor of Numa, was the first victim of the dangerous "heavenly guest" recorded in history. Salverte remarks that Pliny makes use of expressions which seem to indicate two distinct processes; the one obtained thunder (*impetrare*), the other forced it to lightning (*cogere*). Tracing back the knowledge of thunder and lightning possessed by the Etruscan priests, we find that Tarchon, the founder of the theurgism of the former, desiring to preserve his house from lightning, surrounded it by a hedge of the white bryony, a climbing plant which has the property of averting thunderbolts. The Temple of Juno had its roofs covered with numerous pointed blades of swords. Ben David, says the author of "Occult Sciences," has asserted that Moses (born about 1570 B.C.) possessed some knowledge of the phenomena of electricity. Prof. Hirt, of Berlin, is of this opinion. Michaelis remarks that there is no indication that lightning ever struck the Temple of Jerusalem during a thousand years: that, according to Josephus, a forest of points, of gold and very sharp, covered the roof of the temple, and that this roof communicated with the caverns in the hill by means of pipes in connection with the gilding which covered all the exterior of the building, in consequence of which the points would act as conductors. Salverte further asserts that in the days of Ctesias—Ktesias—India was acquainted with the use of conductors

of lightning. This historian plainly states that iron placed at the bottom of a fountain, and made in the form of a sword, with the point upward, possessed, as soon as it was thus fixed in the ground, the property of averting storms and lightning.

"Ancient India, as described by Ktesias, the Knidian," J. H. McCrindle, London, 1882, alludes, p. 68, to iron swords employed to ward off lightning. Reference is made to the *pantarbe* at pp. 7–8, 69–70, and to the *elektron* (amber) at pp. 20, 21, 23, 51, 52, 70, 86. See account of Ktesias in "Nouvelle Biogr. Génér.," Vol. XII. pp. 568–571, and in "Larousse Dict.," Vol. V. p. 614.

In his "Observations sur la Physique," Vols. XXIV. pp. 321–323; XXV. pp. 297–303, XXVI. pp. 101–107, M. l'Abbé Rosier gives the correspondence between M. de Michaelis, Professor at Göttingen, and Mr. Lichtenberg, showing conclusively how the numerous points distributed over the surface of the roof of the Temple of Solomon effectively served as lightning conductors. Mr. Lichtenberg in addition shows that the bell tower located upon a hill at the country seat of Count Orsini de Rosenberg, was, during a period of several years, so repeatedly struck by lightning, with great loss of life, that divine service had to be suspended in the church. The tower was entirely destroyed in 1730 and soon after rebuilt, but it was struck as often as ten times during one prolonged storm, until finally a fifth successive attack, during the year 1778, compelled its demolition. For the third time the tower was reconstructed, and the Count placed a pointed conductor, since which time no damage has been sustained.

REFERENCES.—Mme. Blavatsky, "Isis Unveiled," 1877, Vol. I. pp. 142, 457, 458, 527, 528, and her references to Ovid, "Fast," lib. iii. v. 285–346; Titus Livius, lib. i. cap. 31; Pliny, "Hist. Nat.," lib. ii. cap. 53 and lib. xxviii. cap. 2; Lucius Calp, Piso; Columella, lib. x. v. 346, etc.; La Boissière, "Notice sur les Travaux de l'Académie du Gard," part I. pp. 304–314; "Bell. Jud. adv. Roman," lib. v. cap. 14; "Magas. Sc. de Göttingen," 3e année 5e cahier; Ktesias, in "India ap. Photum. Bibl. Cod.," 72. See also, De La Rive, "Electricity," London, 1858, Vol. III, chap. ii. p. 90; "Encycl. Brit.," 8th ed., article "Electricity"; Lardner, "Lectures," II. p. 99; Humboldt, "Cosmos," 1849, Vol. II. pp. 502–504; Boccalini, "Parnassus," Century I. chap. xlvi. alluded to at p. 24, Vol. I. of Miller's "Retrospect"; Gouget, "Origin of Laws," Vol. III. book 3; Themistius, Oratio 27, p. 337; "Agathias Myrenaeus de rebus gestis Justiniani," lib. v. p. 151; Dutens, "Origine des découvertes . . ."; "Gentleman's Magazine" for July 1785, p. 522; Falconer, "Mem. of Lit. and Phil. Soc. of Manchester," Vol III. p. 278; "Sc. Amer.," No. 7. p. 99; E. Salverte, "Phil. of Magic," 1847, Vol. II. chaps. viii. and ix.; "Fraser's Magazine" for 1839; H. Martin, Paris, 1865–6; P. F. von Dietrich, Berlin, 1784.

B.C. 588.—The earliest reliable record of messages transmitted by the *sign of fire* is to be found in the book of Jeremiah, vi. 1: "O ye children of Benjamin, gather yourselves to flee out of the midst of Jerusalem, and blow the trumpet in Tekoa, and set up a sign

dederat uocem saxis ut diximus respondentem homini imo uero & ob id loquētem Quid lapis rigore pigrius? ecce sensus manusque tribuit illi? Quid ferri duritia pugnatius Sed cedit & patitur morsu trahitur a magnete lapide domitrixq; illa rerū omnium materia ad inane nescio quid currit atque ut propius uenit assistit teneturq; complexuq; hęr&· Syderitū ob id alio nomine uocant quidam heracleon. Magnes appellatus est ab Inuentore ut auctor est Nicander in Ida repertus Nanq; & passim Inueniūtur ut ī hispania quoq; inuenisse autē fertur clauis crepidaꝝ & baculi cuspide haerentibus cum armenta pascer&. Quinque genera magnetis Sotacus monstrat. Aethiopicum & magnesium e macedonia contermina a beboue locatū petentibus dextra Tertium in hyrtio boetię. Quartum circa Alexandriam troadem. Quintum in magnesia asię. Differentia prima mas sit an foemina proxima in colore Nam qui in macedonica magnesia reperiunt̄ ruffi nigriq; sunt boetius uero ruffi coloris plus hab& q̄ nigri qui Troade inuenitur niger & foeminei sexus. Ideoque sine uiribus Deterrimus autem in magnesia asię candidus neq; attrahens ferrū similisq; pumici Compertum tanto meliores esse quanto sunt magis cerulei ęthiopico summa datur pondusq; argento rependitur. Inuenitur ī aethiopia Zmir uraq; uocat̄ regio harcōsa ibi & ematites magnę sanguinei coloris sanguīemq; reddens si terat̄ sed & crocum in attrahendo ferrum non eadem ematiti natura quę magneti aethiopici argumētū est quod magnetem quoq; alium ad se trahit omnes autem hi oculorū medicamētis prosunt ad suā quisq; portionē maxime epiphoras sistunt. Sanant & adusta cremati tritiq;. Alius rursus in eadē ęthiopia nō procul mons qui ferꝝ omne abigit respuitq; de utraq; natura sępius diximus.

LApidē ex Schiro insula integrū fluctuare tradūt eundem mergi Comminutū in asso troadis sarcophagus lapis fissili uena scinditur Corpora defunctorū condita in eo absumi cōstat intra .xl. diē exceptis dentibus Mutianus specula quoq; strigiles & uestes & calciamenta illata mortuis lapidea fieri auctor est. Eius generis in lycia saxa sunt & in oriente quę uiuentibus quoq; adalligata erodunt corpora Mitior est aut seruandis corporibus nec absumendis chemites ebori simillimus in quo Dariū conditum ferunt parioque similis candore & duricia minus tamen ponderosus qui torrus uocatur Theophrastus auctor est & translucidos lapides in ęgypto inueniri quos phio similis aut quod fortassis tunc fuerant quoniam &. ii. desinunt & noui reperiuntur: basius gustatu salsus podagras lenit pedibus in uase ex eo cauato īditis pręterea omnia crurum uitia in his lapidicinis sanant̄ cum metallis omnibus crura uitientur Eiusdem lapidis flos appellatur farina exeo quędā mollis perinde efficax Est aūt similis pumici ruso admixtus ęri alias cerę cyprię Mammarum uitia emēdat pici aūt resinę ue strumas & panos discutit ꝓdē & ptisicis iunctā cū melle ulcera ad Cicatrices ꝑducit excressentia erodit & ad Bestiarum morsus repugnātia curationi suppurata siccat. Fit cataplasma ex eo podagricis mixto fabę lomento.

IDē Theophrastus & Mutiaūs eē aliquos lapides q pariat credūt theophrastus auctor est ebur fossile candido & nigro colore inueniri & ossa e terra nasci Inueniriq; lapides osseos palmati circa mundam in hispania ubi cęsar dictator pompeium uicit reperiuntur. Idq; quotiens fregeris Sunt & nigri quoꝝ auctoritas uenit in marmora sicut tenarius Varro nigros ex aphryca firmiores eē tradit q̄ in Italia. E diuerso albos coranos duriores q̄ parios. Idem lunesem scilicem serra secari tusculanumq; dissilire igni sabinū fuscū addito oleo etiam lucere. Item molas uersatiles a uulsinis īuentas aliquas & sponte motas inuenimus ī prodigiis. Nusq̄ autē utilior q̄ ī Italia gignitur Lapisq; nō est saxū. In quibusdā uero ꝓuinciis omnino nō Inuenit̄. Sunt quidā ī eo genere molliores qui & cote leuigantur ut procul intuentibus ophites uideri possit

Caius Plinius Secundus. Page taken from earliest known edition of the Naturalis Historiae Venetiis 1469, of which there are only three known original vellum copies. These are now at Vienna, Ravenna and in the Bibliothèque Sainte Geneviève, Paris.

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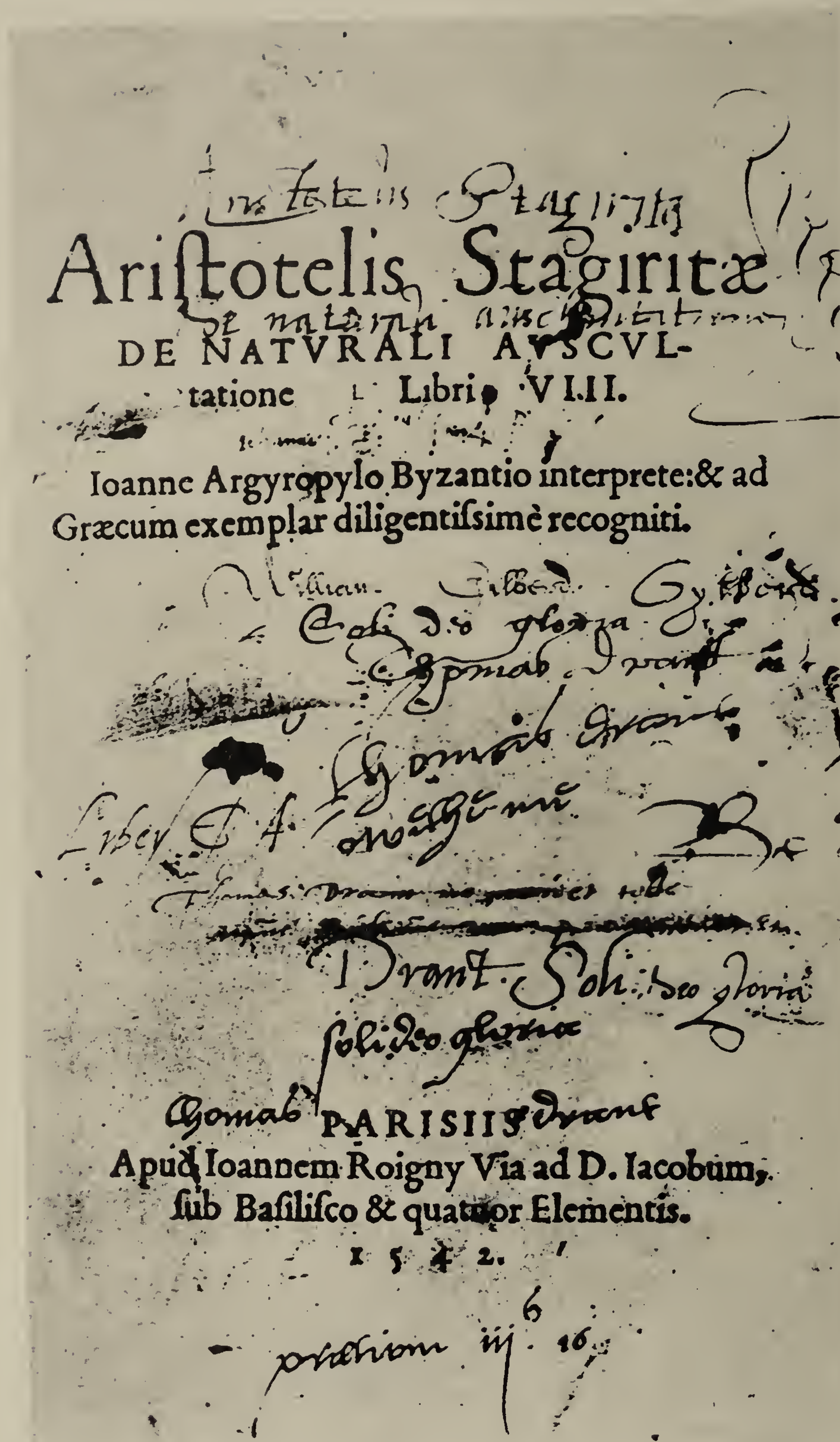

Aristotelis Stagiritæ

DE NATVRALI AVSCVL-
tatione Libri VIII.

Ioanne Argyropylo Byzantio interprete: & ad Græcum exemplar diligentissimè recogniti.

Drant. Soli deo gloria

soli deo gloria

Thomas PARISIIS Drant

Apud Ioannem Roigny Via ad D. Iacobum, sub Basilisco & quatuor Elementis.

1542.

pretium iij. 16.

Title page of Aristotle's "De Naturali Auscultatione," Paris 1542.
The property of Dr. William Gilberd, when at Cambridge,
inscribed with his name and that of Archdeacon Thomas Drant.
(From the Library of Dr. Silvanus. P. Thompson.)

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of fire in Beth-haccerem; for evil appeareth out of the north and great destruction."

REFERENCES.—Turnbull, "Electro-magnetic Telegraph," 1853, p. 17; Knight's "Mech. Dict.," Vol. III. p. 2092; Penny and other Encyclopædias.

B.C. 341.—Aristotle, Greek philosopher, says ("Hist. of Anim.," IX. 37) that the electrical *torpedo* causes or produces a torpor upon those fishes it is about to seize, and, having by that means got them into its mouth, feeds upon them. The *torpedo* is likewise alluded to, notably by (Claudius) Plutarch, the celebrated Greek moralist, by Dioscorides, Pedacius, Greek botanist, referred to in Gilbert's "De Magnete," Book I. chaps. i, ii, and xiv; by Galen, illustrious Roman physician, who is also frequently alluded to in "De Magnete," and by Claudius Claudian, Latin poet, who flourished at the commencement of the fifth century. Oppian describes ("Oppian's Halieuticks of the nature of fishes and fishing of the ancients in five books," lib. ii. v. 56, etc., also lib. iii. v. 149) the organs by which the animal produces the above effect, and Pliny ("Nat. Hist.," Book 32, chap. i) says: "This fish, if touched by a rod or spear, at a distance paralyzes the strongest muscles, and binds and arrests the feet, however swift."

"The very crampe-fish *tarped*, knoweth her owne force and power, and being herself not benummed, is able to astonish others" (Holland "Plinie," Book IX. chap. xlii.).

"We, here, and in no other place, met with that extraordinary fish called the *torpedo*, or numbing fish, which is in shape very like the fiddle fish, and is not to be known from it but by a brown circular spot about the bigness of a crown-piece near the centre of its back" (Ausonius, "Voyages," Book II. chap. xii.).

REFERENCES.—"Encycl. Metr.," IV. p. 41; "Encycl. Brit.," article "Electricity"; Jos. Wm. Moss, "A Manual of Classical Biography," London, 1837, Vol. I. pp. 105–186, for all the Aristotle's treatises, also Commentaries and Translations; Jourdain (Charles et Amable), "Recherches . . . traductions latines d'Aristotle," Paris, 1843; Fahie, "Hist. of Elec. Teleg.," p. 170; "Sci. Amer.," No. 457, pp. 7301, 7302; "Aristotle," by Geo. Grote, London, 1872; Humboldt, "Cosmos," 1859–1860, Vols. I and II *passim*, Vol. III. pp. 13–15, 29–30, 124; "Journal des Savants," for Feb. 1861, March and May 1872, also for Feb., May and Sept. 1893.

Aristotle is alluded to in Gilbert's "De Magnete," at Book I. chaps. i. ii. vii. xv. xvi. xvii.; Book II. chaps. i.[1] iii. iv.; Book V. chap. xii.; Book VI, chaps. iii. v. vi.

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[1] In this Chapter I of Book II Gilbert says that Aristotle admits only of two simple movements of his elements, from the centre and toward the centre . . . so that in the earth there is but one motion of all its parts towards the centre of the world—a wild headlong falling. Johannes Franciscus Offusius (the author of "De divina astrorum facultate," Paris, 1570), says he distinguishes several magnetic movements, the first to the centre, the second to the pole, traversing seventy-seven degrees, the third to iron, the fourth to a loadstone.

B.C. 341.—Æneas, the tactician, believed to be the same Æneas of Stymphale alluded to by Xenophon, invented a singular method of telegraphing phrases commonly used, especially in war. These were written upon exactly similar oblong boards placed at the dispatching and receiving stations, where they stood upon floats in vessels of water. At a given signal the water was allowed to flow out of the vessel at each station, and, when the desired phrase on the board had reached the level of the vessel, another signal was made so that the outflow could be stopped and the desired signal read at the receiving station.

References.—Laurencin, " Le Télégraphe," Chap. I; " Penny Encycl.," Vol. XXIV. p. 145; " Michaud Bio.," Paris, 1855, Vol. XII. pp. 459–460.

B.C. 337–330.—From the well-known work by Mme. Blavatsky (" Isis Unveiled," New York, 1877) the following curious extracts are made regarding " The Ether or Astral Light " (Vol. I. chap. v. pp. 125–162) :

" There has been an infinite confusion of names to express one and the same thing, amongst others, the Hermes-fire, the lightning of Cybelè, the nerve-aura and the fluid of the magnetists, the *od* of Reichenbach, the fire-globe, or meteor-*cat* of Babinet, the physic force of Sergeant Cox and Mr. Crookes, the atmospheric magnetism of some naturalists, galvanism, and finally, electricity, which are but various names for many different manifestations or effects of the same all-pervading causes—the Greek Archeus. . . ." Only in connection with these *discoveries* (Edison's Force and Graham Bell's Telephone, which may unsettle, if not utterly upset all our ideas of the imponderable fluids) we may perhaps well remind our readers of the many hints to be found in the ancient histories as to a certain secret in the possession of the Egyptian priesthood, who could instantly communicate, during the celebration of the Mysteries, from one temple to another, even though the former were at Thebes and the latter at the other end of the country; the legends attributing it, as a matter of course, to the " invisible tribes " of the air which carry messages for mortals. The author of " Pre-Adamite Man " (P. B. Randolph, at p. 48) quotes an instance, which, being merely given on his own authority, and he seeming uncertain whether the story comes from Macrinus or some other writer, may be taken for what it is worth. He found good evidence, he says, during his stay in Egypt, that one of the Cleopatras actually sent news by a wire to all of the cities from Heliopolis (the magnificent chief seat of sun-worship) to the island of Elephantine, on the Upper Nile.

Further on, Mme. Blavatsky thus alludes to the loadstone :

" The stone magnet is believed by many to owe its name to Magnesia. . . ." We consider, however, the opinion of the Hermetists

to be the correct one. The word *magh, magus,* is derived from the Sanscrit *mahaji,* meaning the great or wise . . . so the magnet stone was called in honour of the Magi, who were the first to discover its wonderful properties. Their places of worship were located throughout the country in all directions, and among these were some temples of Hercules, hence the stone—when it became known that the priests used it for their curative and magical purposes—received the name of Magnesian or Herculean stone. Socrates, speaking of it, says: "Euripides calls it the Magnesian stone, but the common people the Herculean" (Plato, "Ion"—Burgess—Vol. IV. p. 294). In the same Vol. I. of "Isis Unveiled," we are likewise informed that Electricity in the Norse legends is personated by Thor, the son of Odin, at Samothrace by the Kabeirian Demeter (Joseph Ennemoser, "History of Magic," London, 1854, Vol. II.; J. S. C. Schweigger, "Introd. to Mythol. through Nat Hist.," Halle, 1836), and that it is denoted by the "twin brothers," the Dioskuri. Also that the *celestial,* pure fire of the Pagan altar was electrically drawn from the astral light, that magnetic currents develop themselves into electricity upon their exit from the body, and that the first inhabitants of the earth brought down the heavenly fire to their altars (J. S. C. Schweigger in Ennemoser's "Hist. of Magic," Vol. II. p. 30; Maurus Honoratus Servius, "Virgil," Eclog. VI. v. 42).

B.C. 321.—Theophrastus, Greek philosopher, first observed the attractive property of the *lyncurium,* supposed by many to be the *tourmaline,* and gave a description of it in his treatise upon stones ("De Lapidibus," sec. 53; or the translation of Sir John Hill, 1774, chap. xlix.–l., p. 123). This crystal was termed *lapis lyncurius* by Pliny in his "Nat. Hist.," and *lapis electricus* by Linnæus in his "Flora Zeylanica" (U. Aldrovandus, "Mus. Metal."; Philemon Holland, "The Historie of the World," commonly called "The Naturall Historie of C. Plinius Secundus," London, 1601).

Theophrastus and Pliny speak of this native magnet as possessing, like amber, the property of attracting straw, dried leaves, bark and other light bodies. The different sorts of loadstones, of which the best were blue in colour (as stated by Taisnier, Porta, Barthol. de Glanville and others), are thus alluded to by Pliny ("Nat. Hist.," lib. xxxvi. cap. 16): "Sotacus describes five kinds: the Æthiopian; that of Magnesia, a country which borders on Macedonia; a third from Hyettus, in Boetia; a fourth from Alexandria, in Troas; and a fifth from Magnesia, in Asia" (Porta, "Natural Magick," Book VII. chap. i.). He further says that iron cannot resist it; "the moment the metal approaches it, it springs

toward the magnet, and, as it clasps it, is held fast in the magnet's embrace." It is by many called *ferrum vivum*, or quick iron.[1]

Claudian speaks of it as "a stone which is preferred to all that is most precious in the East. . . . Iron gives it life and nourishes it" (Claudian, Idyl V; Ennemoser, "Hist. of Magic," Vol. II. p. 27).

Hippocrates, the father of medical science, calls it "the stone which carries away iron."

Epicurus, an Athenian of the Ægean tribe, says: "The *loadstone or magnet* attracts iron, because the particles which are continually flowing from it, as from all bodies, have such a peculiar fitness in form to those which flow from iron that, upon collision, they easily unite. . . . The mutual attraction of *amber* and like bodies may be explained in the same manner."

Hier. Cardan intimates that "it is a certain appetite or desire of nutriment that makes the loadstone snatch the iron . . ." ("De Subtilitate," Basileæ, 1611, lib. vii. p. 381).

Diogenes of Apollonia (lib. ii. "Nat. Quæst.," cap. xxiii.) says that "there is humidity in iron which the dryness of the magnet feeds upon."

Cornelius Gemma supposed invisible lines to stretch from the magnet to the attracted body, a conception which, says Prof. Tyndall, reminds us of Faraday's lines of force.

Lucretius accounts for the adhesion of the steel to the loadstone by saying that on the surface of the magnet there are hooks,

[1] At p. 16, note No. 4, of his "Dawn of Civilization," New York, 1894, Mr. G. Maspero says that the well-known French archæologist, Charles Théodule Deveria (1831–1871), was the first to prove that the Egyptians believed the sky to be made of iron or steel. This was done in his monograph entitled "Le fer et l'aimant, leur nom et leur usage dans l'ancienne Egypte," published originally at Paris during 1872 in "Mélanges d'Archéologie," Vol. I. pp. 2–10; also by M. Charas, in "l'antiquité Historique," first edition, pp. 64–67, and at pp. 339–356, Vol. V. of the "Bibliothèque Egyptologique," issued in Paris during 1897. So well established was the belief in a sky-ceiling of iron, says M. Charas, that it was preserved in common speech by means of the name given to the metal itself, viz. *Bai-ni-pit* (in the Coptic, *Benipi, benipe*)—*metal of heaven.* Reference is thereto made in "The Transactions of the Royal Society of Literature," Vol. XIV. second series, p. 291, by Mr. J. Offord, Jr., who speaks of the splendid and exceedingly valuable papyrus in the Louvre "Catalogue des Manuscripts," Paris, 1874, pp. 170–171 of M. Deveria, who frequently referred to it in the preparation of the monograph above alluded to upon Iron and the Loadstone in Ancient Egypt ("Zeitschrift für Ægyptische Sprache und Alterthumskunde"—Review founded by M. le Docteur H. Brugsch). Deveria says: "Cette matière céleste (dont parle Plutarque) devait être l'aimant, la substance d'Horus, la siderites des Romains, plutôt que le fer non-magnétique, substance typhonienne. . . . Ils disent aussi que la pierre d'aimant est un des os de Horus et le fer un des os de Typhon: c'est Manathon qui nous l'apprend." For Deveria, see "La Grande Encyclopédie," H. Lamirault et Cie., Paris, n. d., Vol. XIV. p. 375.

and, on the surface of the steel, little rings which the hooks catch hold of.

Thales, Aristotle, Anaxagoras of Clazomenæ and the Greek sophist Hippias, ascribe the loadstone's attractive virtue to the *soul* with which they say it is endowed. Humboldt (" Cosmos," article on the Magnetic Needle) says *soul* signifies here " the inner principle of the moving agent," and he adds in a footnote : " Aristotle (" De Anima," I. 2) speaks only of the animation of the magnet as of an opinion that originated with Thales." Diogenes Laertius interprets this statement as applying also distinctly to amber, for he says : " Aristotle and Hippias maintain as to the doctrine enounced by Thales."

The native magnet appears to have long been known in nearly every quarter of the globe (Humboldt, " Cosmos," 1848, Vol. V, and Harris, " Rudimentary Magnetism," Parts I and II).

In the Talmud, it is called *achzhàb'th,* the stone which attracts; in the Aztec, *tlaihiomani tetl,* the stone that draws by its breath; in the Sanscrit, *ayaskânta,* loving toward iron; in the Siamese, *me-lek,* that which attracts iron; in the Chinese, *thsu-chy,* love stone, also *hy-thy-chy,* stone that snatches up iron; in the French, *l'aimant,* and in the Spanish, *iman,* loving stone; in the Hungarian, *magnet kö,* love stone; while in the Greek it is called *siderites,* owing to its resemblance to iron.

For *lyncurium* of the ancients see *Phil. Trans.*, Vol. LI. p. 394, and Hutton's " Abridgments," Vol. XI. p. 419.

Euripides (" Fragmenta Euripidis," Didot edit., 1846, p. 757) called it *lapis herculaneus,* from its power over iron, and it was also known as *lapis heracleus,* doubtless because the best was, at one time, said to be found near Heraclea in Lydia (Plato, " Ion " —Burgess—Vol. IV. p. 294; see, besides, Blavatsky, " Isis Unveiled," Vol. I. p. 130; Hervart (J. F.), Ingolstadii, 1623).

It has likewise been designated as follows : Chinese, *tchu-chy,* directing stone; Icelandic, *leiderstein,* leading stone; Swedish, *segel-sten,* seeing stone; Tonkinin, *d'ànamtchûm,* stone which shows the south; and, by reason of its great hardness, the Greeks called it *calamita;* the Italians *calamita;* the French *calamite,* also *diamant;* the Hebrews *khalamish* or *kalmithath,* and the Romans *adamas,* while *adamant* was the name given to the magnetic needle (compass) by the English of the time of Edward III (T. H. H. Martin, " De l'aimant, de ses noms divers et de ses variétés," Paris, 1861; Buttmann, " Bemerkungen . . . des Magnetes und des Basaltes," 1808, Band II.; G. A. Palm, " Der Magnet in Alterthum," 1867).[1]

[1] The word *calamita* was first used by the Italians. It is employed by Petri de Vineis (Pierre des Vignes), Matthieu de Messine, the notary of

"This stone adamas is dyuers and other than an Magnas, for yf an adamas be sette by yren it suffryth not the yren come to the magnas, but drawyth it by a manere of vyolence fro the magnas" (Trevisa, "Barth. de Prop. reb.," XVI. 8).[1]

"The adamant cannot draw yron if the diamond lye by it" (Lyly, "Euphues," sig. K. p. 10).

"Right as an adamound, iwys, can drawen to hym sotylly the yren" ("Rom. Rose").

"In Ynde groweth the admont stone . . . she by her nature draweth to her yron" (Caxton, "Myrrour," II. vii. 79).

"The adamant placed neare any iron will suffer it to be drawen away of the lode stone" (Maplet, "Greene Forest," I.).

"You draw me, you hard-hearted adamant; but yet you draw not iron; for my heart is true as steel" (Shakespeare, "Midsum. Night's Dream," Act. ii. sc. 1).

"As sun to day, as turtle to her mate, as iron to adamant" (Shakespeare, "Troilus and Cressida," Act iii. sc. 2).

"The grace of God's spirit, like the true load stone or adamant, draws up the yron heart of man to it" (Bishop Hall, "Occas. Medit.," 52.).

Lentino, and by Guido Guinicelli of Bologna (Libri, "Hist. des Sc. Mathém.," Vol. II. pp. 66–69). Consult likewise C. Falconet, "Dissert Histor.," Paris, 1746; "Le Journal des Sçavans" for July–December 1724, Vol. LXXV. pp. 22–28; W. Falconer, Vol. III. of the "Mem. of the Society of Manchester," also "Bibl. Britan.," 1798, Vol. VIII. p. 281.

In the "Essai d'un Glossaire Occitanien" ("Le Journal des Savants" for June 1820, pp. 369–370) it is said about M. de Rochegude that he discovered in "La Vie de St. Honorat de Lérins," written by Raimont Féraut in 1300, the words *caramida, caramita,* which he interprets as *calamite, aimant, boussole,* and that he also read in the "Bergeries" of Remy Belleau (1528–1577) the words *calamite ou aiguille aimantée.* He found that Joachim du Bellay (1524–1560) had written "Comme le fer qui suit la calamite," and Nicholas Rapin (1540–1608) "Tourne ma calamite," but, after examining all the ancient works obtainable, he concluded that the poem of Raimont Féraut, admitted by him to have been translated from an old Latin MS., is the earliest publication containing the word adopted by many to designate the compass. The poem alluded to is the only one extant of Raimont Féraut—Raymond Féraudi de Thoard—a troubadour, long at the court of Charles II of Naples, who died about A.D. 1324 ("Biogr. Génér."—Hœfer—Vol. XVII. p. 354).

[1] "If an adamant be set by iron, it suffereth not the iron to come to the magnet, but it draweth it by a manner of violence, from the magnet, so that though the magnet draweth iron to itself, the adamant draweth it away from the magnet" (Mediæval Lore, "Gleanings from Barthol. de Glanvilla," by Robert Steele, London, 1893, Chap. IX. p. 32). The great "Liber de Proprietatibus Rerum," which has been elsewhere cited in this compilation, was undoubtedly written by Glanvilla (who, according to Salimbene, author of the "Chronicles of Parma," had been a professor of theology in the Paris University) before the year 1260, for, as Steele remarks, he cites Albertus Magnus, who was in Paris during 1248, but does not quote from either Vincent de Beauvais, Thomas Aquinas, Roger Bacon or Egidius Colonna, all of whom were in Paris during the second half of the thirteenth century.

"The adamant . . . is such an enemy to the magnet that, if it be bound to it, it will not attract iron" (Leonardus, "Mirr. Stones," 63).

According to Beckmann (Bohn, 1846, pp. 86–98) the real *tourmaline* was first brought from Ceylon (where the natives called it *tournamal*), at the end of the seventeenth century or beginning of the eighteenth century (see A.D. 1707).

It is classed by Pliny as a variety of carbuncle (lib. xxxvii. cap. vii.). John de Laet says ("De Gemmis," 1647, 8vo, p. 155): "The description of the *lyncurium* does not ill agree with the hyacinth of the moderns." Watson thinks likewise ("Phil. Trans.," Vol. LI. p. 394) and so does John Serapion-Serapio Mauritanus—Yuhanna Ibn Serapion Ben Ibrahim (alluded to by Gilbert, "De Magnete," Book I. chap. i.) in his "Lib. de simplicibus medicinis," Argent. 1531, fol. p. 263; and Anselm Boëce de Boot, Flemish naturalist ("Gem. et Lap. Hist.," Leyden, 1636); while Epiphanius ("De Gemmis," XII.) states that he could find in the Bible no mention of the *lyncurium*, which latter he also believes to have been the hyacinth. On the other hand, the Duke de Noya Caraffa ("Recueil de Mém. Æpinus," Petersb. 1762, 8vo, p. 122) considers the *tourmaline* to be identical with the *theamedes* of the ancients (Pliny, lib. xx. 50, and xxxvi., 25; Cardan, "De Subtilitate," lib. vii. p. 386).

The *betylos* has doubtless been likewise named in this connection. Strabo, Pliny, Helancius—all speak of the electrical or electro-magnetic power of the betyli. They were worshipped in the remotest antiquity in Egypt and Samothrace as magnetic stones "containing souls which had fallen from heaven," and the priests of Cybelè wore a small *betylos* on their bodies (Blavatsky, "Isis Unveiled," Vol. I. p. 332).

REFERENCES.—Enfield, "Dict. Phil.," I. 152: Marbodeus Gallus, 1530–1531 Friburg, pp. 41 and 1539, Cologne, p. 39; Bostock's "Pliny," Book XXXVII. chap. xii.; Azuni, "Boussole," 1809, p. 37; Venanson, "De l'invention de la Boussole Nautique," Naples, 1808, pp. 27–29; Thomas, "Sc. An.," 1837, p. 250. See also De Noya, "Encycl. Brit.," 1855, VIII. p. 529, and Priestley, "History of Electricity," 1775, p. 293; A. Cæsalpini, "De Metallicis," Romæ, 1596; Th. Browne, "Pseudodoxia Epidemica," 1650, p. 51; St. Isidore, "Originum," lib. xvi. cap. 4; Corn. Gemma, "De Natura Divinis," lib. i. cap. 7; Alb. Magnus, "De Mineral.," lib. ii.; Joseph Ennemoser, "History of Magic," Vol. II. pp. 27, 29, 51; Julius Solinus, "De Mirabilibus," cap. 34; Johann S. T. Gehler, "Physik. Wörterbuch," article "Magnetismus"; Joannes Langius, "Epistolarum Med.," Epist. lxxv. For extract of Serapio's work see Fernel's "Coll. . . . Greek Writers," 1576. Consult likewise "Collection des anciens Alchimistes Grecs," par M. Marcellin Berthelot, Paris, 1887, p. 252: *siderites, aimant* ou *magnes, ferrum vivum,* mâle et femelle—with references to Dioscorides, Pliny and Lexicon Alch. Rulandi.

For Pliny, see also "Manual of Classical Biography," by Jos. Wm. Moss, London, 1837, Vol. I. pp. 473–504.

"For lyke as ye lodestone draweth vnto it yron: so doeth beneficence and well doyng allure all men vnto her."—Udal. Markè, c. 5.

B.C. 285–247.—Ptolemy (Ptolemæus II, surnamed *Philadelphus*, or the brother-loving, son of Ptolemy *Soter*) ordered Timochares, the architect of the palace, to suspend the iron statue of Arsinoë in the temple of Pharos.

Although Pliny says (lib. xxxiv. cap. 14) that the statue was never completed owing to the death of both Ptolemy and his architect, Ausonius (Decimus Magnus), Roman poet (A.D. 309–393), asserts the contrary in his most important work, "Mosella" (vv. 314–320), translation of Mr. de la Ville de Mirmont, the first edition of which was published by Ugollet at Venice in 1499. Therein it is said: "Timochares (and not Dinochares, Dinocrates, Demochrates or Chirocrates) suspended the statue in mid-air (*dans les hauteurs aëriennes du temple*). . . . Under the ceiling-vault crowned with loadstones, a bluish magnet draws, by means of an iron hair, the young woman it holds in its embrace."

"Dinocrates began to make the arched roofe of the temple of Arsinoë all of magnet, or this loadstone, to the end, that within that temple the statue of the said princesse made of yron, might seeme to hang in the aire by nothing" (Holland, "Plinie," Book XXXIV. cap. 14).

King Theodoric alludes (Cassiodor, "Variar," lib. i. epist. 45) to a statue of Cupid in the temple of Diana at Ephesus (one of the seven Wonders of the World), and St. Augustine ("De Civitate Dei," XXI. 6) speaks of a bronze figure in the temple of Serapis at Alexandria, both suspended by means of a magnet attached to the ceiling.[1]

REFERENCES.—De Mirmont, "La Moselle," 1889, "Commentaire," pp. 93 and 95; St. Isidore, "Originum," lib. xvi. cap. 4; G. Cedrinus, "Compend. Hist.," cap. 267; Knight's "Mech. Dict.," Vol. II. p. 1370; Knight's "Cyclopædia," Vol. I. p. 363; J. Ennemoser, "Hist. of Magic," Vol. II. p. 35; Ath. Kircher, "Magnes," 1643, lib. ii. prob. vi.; Dinochares, with translation of poem (Claudian, Idyl V) at pp. 61–62 of "Antique Gems," by Rev. C. W. King, London, 1866; Vincent de Beauvais, "Spec. Mai," Douai, 1624, Vol. I., lib. viii. cap. 34; Alb. Magnus, "De Mineralibus," 1651, lib. ii. cap. 6, p. 243; Ausonio Lucius Ampelius, "Lib. Memorialis," Paris, 1827, cap. viii.; T. H. Martin, "Observ. et Théories," 1865, pp. 5–7; Thos. Browne, "Pseud. Epidem.," 1658, Book II. p. 79; W. Barlowe's "Magneticall Advertisements,"

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[1] It is scarcely necessary to add that the afore-named method of suspension is impracticable. This curious problem was deemed worthy of a memoir by M. J. Plateau, communicated to the "Académie des Sciences" at its *séance* of November 28, 1864 ("Le Moniteur Scientifique," par le Dr. Quesneville, Vol. VI. p. 1146).

1616, p. 45; "Simonis Maioli . . . dies Caniculares, seu Colloqui, XXIII," 1597, p. 782; Ruffinus, "Prosper d'Aquitaine"; Porta, "Magia Naturalis," lib. vii. cap. 27; "Mosella," in Wernsdorf's "Poetæ Latini Minores"; E. Salverte, "Phil. of Magic," 1847, Vol. II. p. 215.

B.C. 200.—Polybius, a Greek statesman and historian, describes (lib. x. cap. 45, "General History") his optical telegraph—*pyrsia*—because the signals were invariably produced by means of fire-lights—an unquestionable improvement upon the modes of communication which had been previously suggested by Cleoxenes and Democritus. It consisted of a board upon which the twenty-four letters of the Greek alphabet were arranged in five columns, one space being vacant. The party signalling would hold up with his left hand a number of torches indicating the column from which the desired letter was to be taken, while in the right hand he would hold up to view as many torches as were necessary to designate the particular letter required.

References.—Rollin's "Ancient History, 9th Dundee," Vol VI. p. 321; "Emporium of Arts and Sciences," Vol. I. pp. 296–299; "Penny Encycl.," Vol. XXIV. p. 145. A good cut of the Polybius telegraph will be found at p. 2 of "Wireless Telegraphy," by Wm. Maver, Jr., New York, 1904, and a very detailed account of all known fire signals is given at pp. 148 and 373, Vol. IV of "The History of Herodotus," by Geo. Rawlinson, London, 1880.

B.C. 60–56.—Lucretius (Titus Lucretius Carus), Roman poet, alludes to the magnet in his poem "De Rerum Natura" ("The Nature of Things"), thus translated by Dr. Thomas Busby, London, 1813, Book VI. vv. 1045–1059:

"Now, chief of all, the Magnet's powers I sing,
And from what laws the attractive functions spring.
(The Magnet's name the observing Grecians drew
From the Magnet's region where it grew.)
Its viewless, potent, virtues men surprise;
Its strange effects they view with wondering eyes,
When without aid of hinges, links or springs,
A pendent chain we hold of steely rings,
Dropt from the stone; the stone the binding source,
Ring cleaves to ring, and owns magnetic force;
Those held superior those below maintain;
Circle 'neath circle downward draws in vain,
While free in air disports the oscillating chain.
So strong the Magnet's virtue as it darts
From ring to ring and knits the attracted parts."

A rendering by Thomas Creech, A.M., London, 1714, Book VI. vv. 894–989, likewise deserves reproduction here:

"Now sing my muse, for 'tis a weighty cause.
Explain the Magnet, why it strongly draws,
And brings rough Iron to its fond embrace.
This, Men admire; for they have often seen
Small Rings of Iron, six, or eight, or ten,
Compose a subtile chain, no Tye between;

But, held by this, they seem to hang in air,
One to another sticks and wantons there;
So great the Loadstone's force, so strong to bear!
. . . .
First, from the MAGNET num'rous Parts arise,
And swiftly move; the STONE gives vast supplies;
Which, springing still in Constant Streams, displace
The neighb'ring air and make an EMPTY SPACE;
So when the STEEL comes there, some PARTS begin
To leap on through the VOID and enter in.
. . . .
The STEEL will move to seek the STONE'S embrace,
Or up or down, or t' any other place,
Which way soever lies the EMPTY SPACE."

The transmission of the magnetic attraction through rings or chains is also alluded to in Plato's "Ion," p. 533, D. E. Ed. Stephanus; by Pliny, lib. xxxiv. cap. 14; St. Augustine, "De Civitate Dei," XX. 4; Philo, "De Mundi Opificio," D. ed., 1691, p. 32; likewise by the learned Bishop Hall, "The English Seneca," as follows: "That the loadstone should by his secret virtue so drawe yron to it selfe that a whole chaine of needles should hang by insensible points at each other, only by the influence that it sends downe from the first, if it were not ordinary, would seeme incredible" ("Meditations," 1640, con. 3, par. 18).

REFERENCES.—"Le Journal des Savants" for January 1824, p. 30, also for March 1833, June 1866 and December 1869; Plutarch, "Platon. Quæst.," Vol. II. p. 1004, ed. par.; St. Isidore, "Etymologiarum, Originum," lib. xvi., iv.; the Timæus (Bohn, 1849, Vol. II. p. 394); Platonis, "Io," Lugduni, 1590, pp. 145, 146; "Houzeau et Lancaster, Bibliographie Générale," Vol. I. part i. pp. 440–442; Geo. Burgess, tr. of Plato's "Ion," London, 1851, Vol. IV. pp. 294–295 and notes.

A.D. 50.—Scribonius Largus, Designationus, Roman physician, relates (Chaps. I. and XLI. of his "De Compositione Med. Medica") that a freedman of Tiberius called Anthero was cured of the gout by shocks received from the electric *torpedo*, and Dioscorides advises the same treatment for inveterate pains of the head ("Torpedo," lib. ii.). Other applications are alluded to by Galen ("Simp. Medic.," lib. xi.; Paulus Ægineta, "De Re Medica," lib. vii.; "Encycl. Met.," article "Electricity," IV. p. 41). See also Bertholon, "Elec. du Corps Humain," 1786, Vol. I. p. 174.

Fahie states ("History of Electric Telegraphy," p. 172) that, along the banks of the Old Calabar River, in Africa, the natives employ the electrical properties of the *gymnotus* for the cure of their sick children. They either place the ailing child close by the vessel of water containing the animal, or the child is made to play with a very small specimen of the fish.

REFERENCES.—"La Grande Encycl.," Vol. XXIX. p. 831; Humboldt, "Voyage Zoologique," p. 88; "New Gen. Biogr.," London,

1850, Vol. XI. p. 501; "Larousse Dict.," Vol. XIV. p. 427; "Hœfer Biogr.," Vol. XLIII. p. 654.

A.D. 121.—The Chinese knew of old the magnet, its attractive force and its polarity, but the most ancient record made of the peculiar property possessed by the loadstone of communicating polarity to iron is explicitly mentioned in the celebrated dictionary "Choue-Wen," which Hin-tchin completed in A.D. 121, the fifteenth year of the reign of the Emperor Ngan-ti of the Han dynasty.

This dictionary contains a description of the manner in which the property of pointing with one end toward the south may be imparted to an iron rod by a series of methodical blows, and alludes to ("Tseu") the "stone with which a direction can be given to the needle."

"In Europe it has been thought that the needle had its chief tendency to the north pole; but in China the south alone is considered as containing the attractive power" (Sir G. Staunton, "Account of an Embassy," London, 1797, Vol. I. p. 445).

Le Père Gaubil, who was sent to China in 1721 and died in Pekin 1759, says ("Histoire . . . de la dynastie de Tang," in "Mémoires concernant . . ." Vol. XV) that he found, in a work written towards the end of the Han dynasty, the use of the compass distinctly marked to distinguish the north and the south. He also states, though doubtless erroneously, that that form was given it under the reign of Hian-Tsoung.

With reference to the magnetic attraction to the pole, it is well to bear in mind that no allusion whatsoever is made thereto by any of the writers of classical antiquity. This much has already been stated under date B.C. 1000–907. It certainly appears to have escaped the attention of the ancient Greeks and Romans, whose admiration, according to the learned French physician Falconet ("Dissert. Hist. et Crit"), was excited solely by the attractive property of the loadstone.

The Rev. Father Joseph de Acosta ("Natural and Moral History of the Indies," translation of C. R. Markham, lib. i. cap. 16) thus alludes to the above subject: "I finde not that, in ancient bookes, there is any mention made of the vse of the Iman or Loadstone, nor of the Compasse (*aguja de marear*) to saile by; I beleeve they had no knowledge thereof. . . . Plinie speakes nothing of that vertue it hath, alwaies to turne yron which it toucheth towards the north. . . . Aristotle, Theophrastus, Dioscorides, Lucretius, Saint Augustine, nor any other writers or Naturall Philosophers that I have seene, make any mention thereof, although they treat of the loadstone."

Thomas Creech, in the notes to his translation of Lucretius'

"De Natura" says: "Nor indeed, do any of the ancients treat of this last (the directive) power of the loadstone . . . and Guido Pancirollus justly places it among the modern inventions."

References.—Klaproth, "La Boussole," Paris, 1834, pp. 9, 10, 66; Azuni, "Boussole," Paris, 1809, p. 30; "English Cycl."—Arts and Sciences—Vol. V. p. 420; Humboldt, "Cosmos," 1848, Vol. II. p. 628; John Francis Davis, "The Chinese," London, 1836, Vol. II. pp. 221, etc., or the 1844 edition, Vol. III. p. 12; Geo. Adams, "Essay . . ." 1785, p. 428.

A.D. 218.—Salmasius, in his Commentary upon Solinus, asserts that, at this date, amber was known among the Arabs as *Karabe*, or *Kahrubá*, a word which, Avicenna states, is of Persian origin and signifies the power of attracting straws; the magnet being called *Ahang-rubá*, or attractor of iron.

References.—"Encycl. Met.," Vol. IV. p. 41; Fahie, "Hist. of Elec. Teleg.," p. 29.

A.D. 232–290.—Africanus (Sextus Julius), an eminent Christian historical writer, author of a chronicle extending from the date of the creation to A.D. 221, as well as of an extensive work entitled "Kestoi," states that the Roman generals perfected a system for readily communicating intelligence by means of fires made of different substances.

References.—Shaffner, "Teleg. Man.," 1859, p. 19; Appleton's "Cyclopædia," 1871, Vol. XV. p. 333.

A.D. 235.—It is related that one Makium, who was ordered by the Chinese emperor to construct "a car which would show the South," succeeded in doing so, and thus recovered the secret of manufacture which had for some time been lost. The "Amer. Journ. of Science and the Arts" (Vol. XL. p. 249) adds that, from this date, the construction of a magnetic car seems to have been a puzzle . . . and the knowledge of the invention appears to have been confined within very narrow limits. Humboldt says that the magnetic wagon was used as late as the fifteenth century of our era; the "American Journal" states that it cannot be traced later than 1609.

A.D. 265–419.—What is by many believed to be the earliest reliable, distinct mention or actually printed record of the use of the magnet for navigation, appears in the justly prominent Chinese dictionary or rather encyclopædia, "Poei-wen-yun-fou," wherein it is mentioned that there were during this period (that of the second Tsin dynasty) ships directed to the South by the *ching* or needle. It is likewise therein stated that the figure then placed upon the magnetic cars represented "a genius in a feather dress" and that,

when the emperor went out upon state occasions this car "always led the way and served to indicate the four points of the compass."

References.—Homer at B.C. 1000–907; Davis, "The Chinese," Vol. III. p. 12; Klaproth, "Boussole," pp. 66, 67; Johnson, "Univ. Cycl.," Vol. I. p. 927, ed. 1877; Miller, "Hist. Phil. Illust.," London, 1849, Vol. I. p. 180.

In a later work called "Mung-khi-py-than" will be found the following: "The soothsayers rub a needle with the magnet stone, so that it may mark the south; however, it declines constantly a little to the east. It does not indicate the south exactly. When this needle floats on the water it is much agitated. If the finger-nails touch the upper edge of the basin in which it floats, they agitate it strongly; only it continues to slide and falls easily. It is preferable, in order to show its virtues in the best way, to suspend it as follows: Take a single filament from a piece of new cotton and attach it exactly to the middle of the needle by a bit of wax as large as a mustard seed. Hang it up in a place where there is no wind. Then the needle always shows the south; but among such needles there are some which, being rubbed, indicate the north. Our soothsayers have some which show the south and some which show the north. Of this property of the magnet to indicate the south, like that of the cypress to show the west, no one can tell the origin."

A.D. 295–324.—Koupho, Chinese physicist as well as writer, and one of the most celebrated men of his age, compares the attractive property of the magnet with that of amber animated by friction and heat. In his "Discourse on the Loadstone" he says: "The magnet attracts iron as amber draws mustard seeds. There is a breath of wind that promptly and mysteriously penetrates both bodies, uniting them imperceptibly with the rapidity of an arrow. It is incomprehensible."

References.—Klaproth, "Boussole," p. 125; Humboldt, "Cosmos," 1848, Vol. V. p. 51; Libri, "Hist. des Mathém.," Vol. I. p. 381, note 2.

A.D. 304.—St. Elmo (St. Erasmus) Bishop of Formiæ, in ancient Italy, who suffered martyrdom about this date at Gæta, is the one after whom sailors in the Mediterranean first named the fires or flames which by many are believed to be of an electric nature and which appear during stormy weather, either at the yardarms, mast-heads, in the rigging, or about the decks of a vessel. When two flames are seen together, they are called Castor and Pollux, "twin gods of the sea, guiding the mariner to port," and are considered by seamen an indication of good luck and of fine weather; but when only one flame is visible it is called Helena, and is supposed to be an evil omen, the beacon of an avenging God luring the sailor to death.

St. Elmo's fire is also known to the Italians as the fire of *St. Peter* and of *St. Nicholas*, to the Portuguese as *San Telmo* and as *Corpos Santos*, and to the English sailors as *comazant* or *corposant*.

The historian of Columbus' second voyage says that during the month of October 1493 "St. Elmo appeared on the topgallant-masts with seven lighted tapers." It is also alluded to by Pliny, "Nat. Hist." lib. ii. cap. 37; by Stobæus, "Eclogarum Phys.," I. 514; Livy, "Hist.," cap. 2; Seneca, "Nat. Quæst.," I. 1; by Cæsar, "de Bello Africano," cap. 6 edit. Amstel., 1686; and by Camoëns, "Os Lusiades," canto v. est. 18.

> "Last night I saw St. Elmo's stars,
> With their glimmering lanterns all at play
> On the tops of the masts and the tips of the spars,
> And I knew we should have foul weather to-day."
> Longfellow, "Golden Legend," Chap. V.

> ". . . Sometimes I'd divide,
> And burn in many places—on the topmast,
> The yards and bowsprit, would I flame distinctly,
> Then meet and join. . . ."
> Shakespeare, "The Tempest," Act i. sc. 2.

References.—"Nouvelle Biographie Générale," Vol. XVI. p. 179; "Grand Dict. Univ. du xix^e siècle" of Pierre Larousse, Vol. VII. p. 786; Humboldt, "Cosmos," 1849, Vol. II. p. 245; Becquerel, "Traité Expér.," 1834, Vol. I. p. 34, and his "Résumé," Chap. I; Le Breton, "Histoire," 1884, p. 43; "La Lumière Electrique," Juin 1891, p. 546, likewise Procopius, "De Bello, Vandal," lib. ii. cap. 2; William Falconer's "Observations," etc. in Vol. III. p. 278 of "Mem. Lit. and Ph. Soc. Manchester," 1790 (translated in Italian, 1791), for an account of the flames appearing upon the spear points of the Roman legions.

A.D. 400.—Marcellus Empiricus, who was *magister officiorum* in the reign of Theodosius the Great (379–395) states in his "De Medicamentis Empiricis," Venetiis, 1547, p. 89, that the magnet called *antiphyson* attracts and repulses iron. This, adds Becquerel in his "Résumé," Chap. III, further proves that these properties were known in the fourth century.

References.—Klaproth, "Boussole," 1834, p. 12; Harris, "Magnetism," I and II; "New Gen. Biogr. Dict.," London, 1850, Vol. IX. p. 475.

A.D. 425.—Zosimus (Count), Greek historian, who lived under Theodosius II (401–450), "sometime advocate of the Treasury of the Roman Empire," wrote the history of that empire from the reign of Augustus to the year A.D. 410, wherein he is the first to call attention to the electrolytic separation of metals, *i. e.* that the latter acquire a coating of copper upon being immersed in a cupreous solution.

References.—Gore, "Art of Electro-Met.," 1877, p. 1, or the London 1890 edition, p. B; "A treatise on Electro-Metal.," by Walter G. McMillan, London, 1890, p. 2; "Journal des Savants" for June 1895, pp. 382–387; Dr. Geo. Langbein's treatise, translated by W. T. Brannt,

Chap. I; "Nouvelle Biogr. Gén." (Hœfer), Vol. XLVI. p. 1022; Schoell, "Hist. de la Littér. Grecque"; Pauly, "Real Encycl. . . . Alterthums"; "Biogr. Univ." (Michaud), Vol. XLV. p. 606; "Nouveau Larousse," Vol. VII. p. 1429.

A.D. 426.—Augustine (Aurelius, Saint), the most prominent of the Latin Fathers of the Church, finishes his "De Civitate Dei," which he began in 413, and which is considered the greatest monument to his genius. He was probably the most voluminous writer of the earlier Christian centuries. He was the author of no less than 232 books, in addition to many tractates or homilies and innumerable epistles ("Books and their Makers, during the Middle Ages," Geo. Haven Putnam, New York, 1896, Vol. I. p. 3). In the "De Civitate Dei" he tells us (Basileæ, 1522, pp. 718–719) of the experiment alluded to herein at A.D. 1558. This had better be given in his own words ("De Civitate Dei," lib. ii. cap. 4, Dod's translation, Edinburgh, 1871):

"When I first saw it (the attraction of the magnet), I was thunderstruck (*vehementer inhorrui*), for I saw an iron ring attracted and suspended by the stone; and then, as if it had communicated its own property to the iron it attracted and had made it a substance like itself, this ring was put near another and lifted it up, and, as the first ring clung to the magnet, so did the second ring to the first. A third and fourth were similarly added, so that there hung from the stone a kind of chain of rings with their hoops connected, not interlinking but attached together by their outer surface. Who would not be amazed by this virtue of the stone, subsisting as it does, not only in itself, but transmitted through so many suspended rings and binding them together by invisible links? Yet far more astonishing is what I heard about the stone from my brother in the episcopate, Severus, Bishop of Milevis. He told me that Bathanarius, once Count of Africa, when the Bishop was dining with him, produced a magnet and held it under a silver plate on which he placed a bit of iron; then as he moved his hand with the magnet underneath the plate, the iron upon the plate moved about accordingly. The intervening silver was not affected at all, but precisely as the magnet was moved backward and forward below it, no matter how quickly, so was the iron attracted above. I have related what I have myself witnessed: I have related what I was told by one whom I trust as I trust my own eyes."

References.—"Vie de St. Augustin," by Poujoulat, second edition, Paris, 1852, and by G. Moringo, 1533; Possidius, also Rivius, "Vitæ de St. Augus."; L. Tillemont, "Mémoires Eccles.," 1702 (the 13th Vol. of which is devoted to an elaborate account of his life and controversies); Bindemann, "Der heilige Augustinus," 1844; Butler, "Lives of the Saints"; Lardner, "Credibility of the Gospel History," Vol. VI. part i. pp. 58–59, and Vol. X. pp. 198–303; Neander, "Geschichte der Christlichen

Religion und Kirche"; Pellechet, "Catalogue Général des Incunables," 1897, pp. 339–370; Alfred Weber, "History of Philosophy," tr. by Frank Thilly, New York, 1896, pp. 188–198; "St. Augustine's City of God," tr. by Rev. Marcus Dods, Edinburgh, 1871, Vol. II. book xxi. pp. 420, 457; "Journal des Scavans," Vol. XIV. for 1686, pp. 22–23, mentions the above-named experiment and the effect of diamond on the loadstone; "Journal des Savants" for Sept. 1898; Ueberweg, "Hist. of Philosophy" (Morris' tr., 1885), Vol. I. pp. 333–346.

A.D. 450.—Aëtius (Amidenus), Greek physician, informs us (Aëtii, op. lib. xi. cap 25) that "those who are troubled with the gout in their hands or in their feet, or with convulsions, find relief when they hold a magnet in their hand. Paracelsus recommended the use of the magnet in a number of diseases, as fluxes, hæmorrhages, etc., while Marcellus ("Steph. Artis. Med. Princip.," II. p. 253) and Camillus Leonardus ("Speculum Lapidum," lib. ii.) assert that it will cure the toothache.

During the year 1596, Jean Jacques Vuccher published "De Secretis" ("The secrets and marvels of Nature"), wherein, at p. 166, he thus advises the application of a loadstone for curing the headache: "*La pierre d'aymant appliquée et mise contre la teste, oste toutes les douleurs et maux d'icelle-ce que nostre Hollerius escrit comme l'ayant prins* [sic] *des commentaires des anciens.*" And, in 1754, Lenoble constructed magnets that were readily used in the treatment of various diseases ("Practical Mechanic," Vol. II. p. 171).

The application of the magnet for the relief of various complaints is treated of at pp. 334–335, Vol. II. of J. Ennemoser's "History of Magic," where will be found a list of works containing accounts of the oldest and most extraordinary known cures on record. Additional references to cures by the magnet, as well as with iron or amber—besides those named more particularly at A.D. 1770 (Maxim. Hell) and at A.D. 1775 (J. F. Bolten)—are to be found in the following works:

Avicenna, "Canona Medicinæ," Venice, 1608, lib. ii. cap. 470; Pliny, "Natural Historie," Holland tr., 1601, Chap. IV. p. 609; Hali Abas, "Liber totius medicinæ," 1523, lib. i.; Serapio Mauritanus, "De simplicibus medicinis," Argent., 1531, pp. 260, 264; Antonius Musa Brasavolus, "Examen omnium simplicium medicamentorum," Rome 1536; Santes de Ardoynis Pisaurensis, "Liber de Venenis" (Venetiis, 1492), Basilæ, 1562; Oribasius, "De facultate metallicorum," lib. xiii.; Joannes Baptista Montanus, "Metaphrasis Summaria . . ." 1551; G. Pictorio, in his poem published at Basel in 1567, or in the 1530–1531 editions of "Marbodei Galli Poetæ vetustissimi de lapidibus pretiosis Enchiridion" (J. A. Vander Linden, "De Scriptis Medicis," 1651, pp. 210–211); Rhazès, "De simplicibus, ad Almansorem," Venetiis, 1542, lib. ult. cap. 295; Joannes Lonicerus (author of "De Meteoris," Frankfort, 1550), "In Dioscoridæ Anazarbei de re medica . . ." 1543, p. 77; Matthæus Silvaticus, "Opus Pandectarum Medicinæ," 1498, 1511, 1526 (1541), cap. 446; Petrus de Abano, "Tractatus de Venenis," 1490, also "Conciliator Differentiarum Philosophorum" (1496), 1520,

1526; Nicolaus Myrepsus, "Liber de compositione medicamentorum," 1541, 1549, 1567, 1626; Joannes Manardus, "Epistolarum medicinalium" (Basilæ, 1549); Dioscorides Pedacius, "De materia medica," Spengel ed., 1829, Chap. CXLVII. or in the 1557 ed. p. 507, or in the translation made by Joannes Ruellius in 1543; Nicholas Monardus, "Joyfull newes out of the new-found worlde," Frampton tr., London, 1596; Arnaldus de Villa Nova, "Tractatus de virtutibus herbarum" (1499); Amatus Lusitanus, "Enarrationes Eruditissimæ," 1597, pp. 482, 507; Gabriellus Fallopius, "De Simplicibus Medicamentis purgentibus tractatus," and "Tractatus de compositione Medicamentorum," Venetiis, 1566, 1570; Joannes Langius, "Epistolarum Medicinalium . . .," Paris, 1589; Petri Andriæ Mathiolus, "Commentarii . . . Dioscoridis . . . de materia medica," 1598, p. 998; W. Barlowe, "Magneticall Advertisements," 1616, p. 7, or the 1843 reprint; Albertus Magnus, "De Mineralibus" (1542), lib. ii.; Oswaldus Crollius, "Basilica Chimica," 1612, p. 267; Nicolaus Curtius, "Libellus de medicamentis . . ." Giessæ Cattorum, 1614; Rudolphi Goclenii—Goclenius—"Tractatus de magnetica curatione," 1609, 1613, also "Synarthosis Magnetica," Marpurgi, 1617 (Eloy "Dict. Hist. de la Méd.," Vol. II. pp. 359–360); Luis de Oviedo, "Methodo de la Coleccion y Reposicion de las medicinas simples," 1622, p. 502; W. Charleton, "A Ternary of Paradoxes of the Magnetic cure of Wounds," 1650; the "Pharmacopœia Augustana," Augsburg, 1621, p. 182; Patrick Brydone in "Phil. Trans.," Vol. L. pp. 392, 695, and Vol. LXIII. p. 163. Consult also the abridgments by Hutton, Vol. XI. p. 262, Vol. XIII. p. 415; Waring's "Bibliotheca Therapeutica," London, 1878.

"The magnet . . . gives comfort and grace, and is a cure for many complaints; it is of great value in disputes. When pulverised, it cures many burns. It is a remedy for dropsy" (I Sermone . . . di F. Sacchetti . . . § 18).

According to Dias, "the magnet reconciles husbands to their wives," and Platea remarks that "it is principally of use to the wounded," while Avicenna says "it is a remedy against spleen, the dropsy and alopecian."

For additional information, consult J. Beckmann's "History of Inventions," Bohn, 1846, Vol. I. p. 43, and the article "Somnambulism" in the "Encyclopædia Britannica."

A.D. 543.—The Japanese say that at about this date the Mikado received from the Court of Petsi in Corea "the wheel which indicates the south."

Reference.—Knight, "Mechanical Dictionary," Vol. II. p. 1397.

A.D. 658.—As shown by Kaï-bara-Tok-sin, in the "Wa-zi-si," the first magnetic cars were constructed during this year in Japan; the loadstone was not, however, discovered in that country until A.D. 713, when it was brought from the province of Oomi (Klaproth, "Boussole," p. 94). The "Journal of the Franklin Institute" (Vol. XVIII. for 1836, p. 69), gives a description and illustration of one of these magnetic chariots, taken from the thirty-third volume of the Japanese Encyclopædia.

A.D. 806–820.—Between these dates, under the Thâng dynasty,

were first made the cars called *Kin-Koung-yuan*, which were magnetic chariots similar to those previously known, but bearing in addition a drum and a bell. Both the latter were struck at regular intervals by an erect male figure placed at the head of the car (" American Journal of Science and the Arts," Vol. XL. p. 249).

A critic named Tchen-yn admits, as already indicated herein under the A.D. 235 date, that the knowledge of the mode of construction of the magnetic cars was by no means general. " I know well," adds he, " that, at the time of the Thâng, under Hien-toung (who ascended the throne 806 A.D., and reigned seventeen years) a chariot was made which always showed the four parts of the earth, in imitation, it was said, of those constructed at the time of Hoang-ti. . . . Upon it stood the figure of a spirit, whose hand always pointed to the south."

References.—" Mémoires concernant l'histoire . . ." by Saillant et Nyon, Paris, 1776–1788, Vol. XIII. p. 234; Klaproth, " Boussole," p. 72.

A.D. 968.—Kung-foo-Whing is said to have invented a method of transmitting sound through wires by means of an apparatus called *thumthsein*, although no trace whatever of the latter is to be found in any of the numerous authorities herein quoted.

A.D. 1067–1148.—Frode (Ari Hinn—Ara Hin—or the Wise), Arius Polyhistor (Ari Prestrinha Frodi Thorgillsun), Icelandic historian, " than whom there is no higher authority," was the first compiler of the celebrated " Landnama-Bok," which contains a full account of all the early settlers in Iceland, and is doubtless the most complete record of the kind ever made by any nation.

In it, he says that, at the time Floke Vilgerderson left Rogoland, in Norway, about A.D. 868, for another visit to Gardansholm (Iceland), of which he was the original discoverer, " the seamen had no loadstone (*leiderstein*) in the northern countries," thus showing, according to Prof. Hansteen, that the directive power of the needle and its use in navigation were known in Europe in the eleventh century. In this manner is given the first intimation of the knowledge of the mariner's compass outside of China. The passage quoted above is by many supposed to be an interpolation, for it is not found in several manuscripts, and it has even been asserted (" Br. Ann.," p. 296), that its origin does not antedate the fourteenth century, thus strengthening the claims of the French in behalf of Guyot De Provins.

References.—" Landnama-Bok," Kiœbenhàven, 1774, T. I. chap. ii. par. 7; John Angell, " Magnet. and Elect.," 1874, p. 10; Lloyd, " Magnetism," p. 101; " Pre-Col. Disc. of Am.," De Costa, pp. xxiii and 11; " Bull. de Géogr.," 1858, p. 177; " Good Words," 1874, p. 70; Klaproth,

"Boussole," p. 40; Hansteen, "Inquiries Concerning the Magnetism of the Earth," and "Magazin für Naturvidenskaberne Christiana," I. 2, "Encycl. Metrop.," Vol. III. p. 736; the 1190–1210 entry herein.

A.D. 1111–1117.—Keou-tsoungchy, Chinese philosopher and writer, gives, in the medical natural history called "Pen-thsao-yan-i," written by him under the Soung dynasty, the earliest description of a water compass found in any Chinese work, viz.: "The magnet is covered over with little bristles slightly red, and its superficies is rough. It attracts iron and unites itself with it; and, for this reason, it is commonly called the stone which licks up iron. When an iron point is rubbed upon the magnet, it acquires the property of pointing to the south, yet it declines always to the east, and is not perfectly true to the south. . . . If the needle be passed through a wick or a small tube of thin reed, and placed upon water, it will indicate the south, but with a continual inclination towards the point *ping*, that is to say, East five-sixths South."

In the "Mung-khi-py-than," also composed under the Soung dynasty, it is stated that fortune-tellers rub the needle with the loadstone in order to make it indicate the south.

References.—*Comptes Rendus*, Vol. XIX. p. 365; "Am. Journal Sc. and Arts," 1841, XL. p. 248; Davis, "The Chinese," 1844, Vol. III. p. 13; Becquerel, "Elec. et Mag.," p. 58; Klaproth, "Boussole," pp. 67–69, 95; Humboldt, "Cosmos," 1849, Vol. II. p. 656, and Vol. V. p. 52; Knight, "Mech. Dict.," Vol. II. p. 1397; Humboldt, "Examen Critique," Paris, 1836, Vol. III. p 34.

A.D. 1160.—Eustathius, Archbishop of Thessalonica, relates in his commentary on the Iliad of Homer, that Walimer, father of Theodoric and King of the Goths, used to emit sparks from his body; also that a certain philosopher observed sparks occasionally issuing from his chest accompanied with a crackling noise.

Leithead tells us that streams of fire came from the hair of Servius Tullius, a Roman King, during sleep, when he was about seven years of age (Dionysius, "Antiq. Rom." lib. iv.; Pliny, "Hist. Nat." lib. ii. cap. 37); that Cardan alludes to the hair of a certain Carmelite monk emitting sparks whenever it was rubbed backward ("De Rerum Varietate," lib. viii. cap. 43); that Father Faber, in his "Palladium Chemicum," speaks of a young woman whose hair emitted sparks while being combed, and also refers to allusions made in the same line by Thomas Bartholinus, "De Luce Animalium," Lugd. 1647, p. 121; Ezekiel di Castro, "De Igne Lambente"; Johann Jacob Hemmer, "Trans. Elec. Soc. Mannheim," Vol. VI; and *Phil. Trans.*, Vol. V. pp. 1, 40.

References.—Eustath in Iliad, E. p. 515, ed. Rom.; "Encycl. Brit.," 1855, VIII. p. 571; Priestley, "History of Electricity," London, 1775, pp. 128, 129; *Phil. Trans.*, abridged, Vol. X. pp. 278, 343, 344, 357.

A.D. 1190–1210.—Guyot de Provins, minstrel at the Court of the Emperor Frederick I (Barbarossa), gives the first French mention of the water compass in a manuscript "politico-satirical" poem entitled "La Bible," to be found in the Bibliothèque Nationale. It is therein said that sailors were at that time in the habit of rubbing needles upon the ugly brown stone called *marinière,* "to which iron adheres of its own accord," and that, as soon as placed afloat upon a small piece of straw in the water, the needles would point to the North. The passage alluding to the compass has been copied by D. A. Azuni, member of the Turin Academy of Sciences, from the original manuscript, and is given entire, with the French translation, at p. 137 of his "Dissertation . . ." second edition, Paris, 1809:

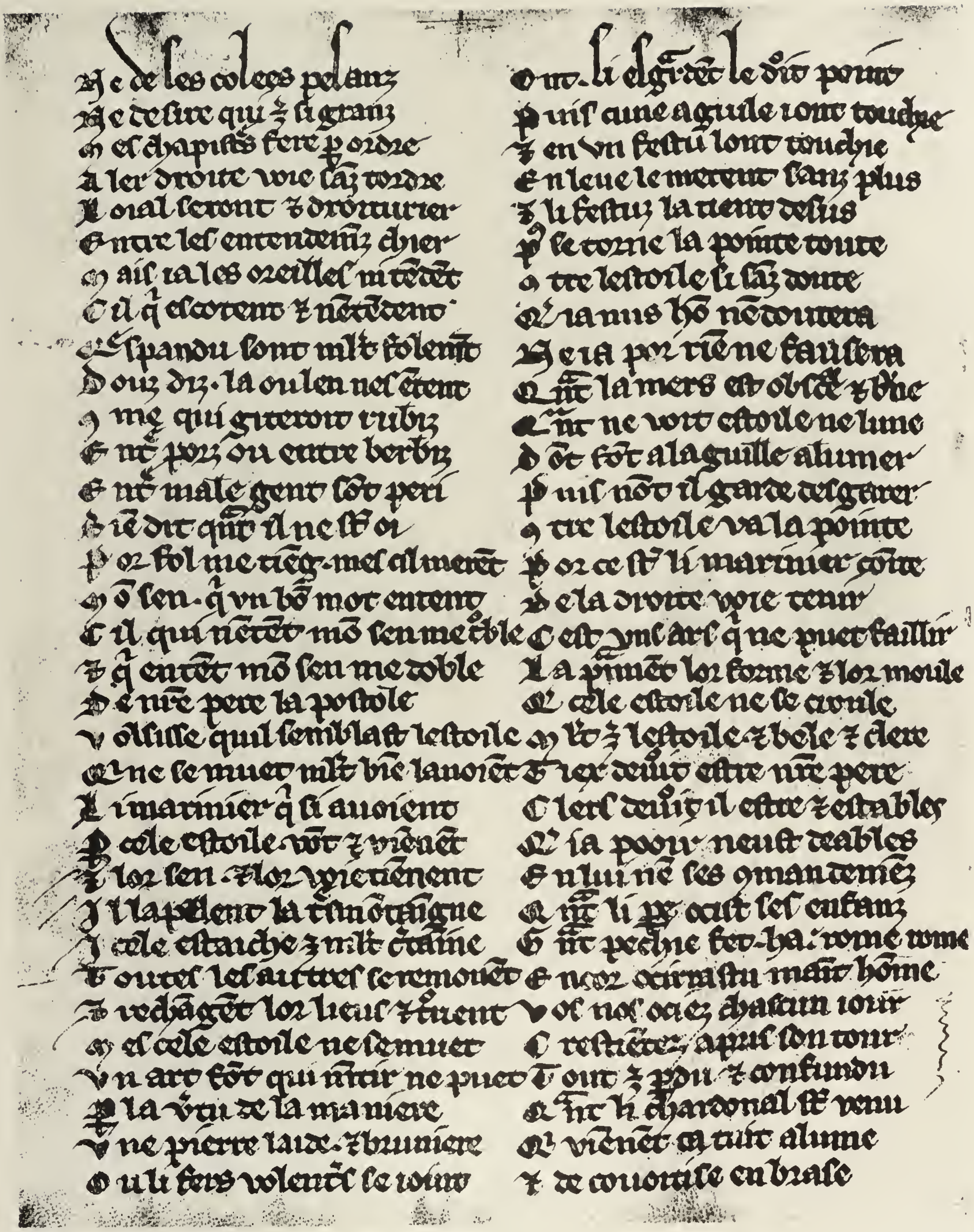
"De notre père l'apostoile (le pape)
. . . . .
Ils l'appellent la tresmontaigne
. . . . .
Par la vertu de la marinière,
Une pierre laide et brumière,
Ou li fers volontiers se joint. . . ."

The passage is also given by Klaproth, at pp. 41–43, and by Venanson, at p. 72, of their respective works already cited; likewise by Bertelli, p. 59 of his Memoir published in 1868.

Sonnini (C. S.), in Buffon "Minéraux," Vol. XV. p. 100, says that Azuni has successfully established the claims of France to the first use of the mariner's compass. Other writers herein, who follow in their order, will doubtless show to the satisfaction of the reader that, as the Arabs possessed it at the same time, they must have received it from the Chinese, and therefore transmitted it to the Franks during the first Crusades, as stated by Klaproth in his "Lettre à M. de Humboldt," Paris, 1834, pp. 64–66.

References.—Becquerel, "Traité d'Elect. et de Magn.," Vol. I. p. 70; Bertelli, "Mem. sopra P. Peregrino," 1868, p. 59; R. M. Ferguson, "Electricity," 1867, p. 43; J. F. Wolfart, "Des Guiot von Provins," Halle, 1861; "Bulletin de Géographie," 1858, p. 177; Barbazan, "Fabliaux," Vol. II. p. 328: Becquerel, "Résumé," Chap. III; Humboldt, "Cosmos," 1849, Vol. II. pp. 628–630; "Amer. Journ. Sc. and Arts," Vol. XL. p. 243; "Guiot von Provins," in Meyers Konvers. Lex., Vol. VIII. p. 81; "Encycl. Met.," Vol. III. p. 736, gives a verbatim copy of part of Guyot's poem, with its literal translation; Libri, "Hist. des Sc. Mathém.," Paris, 1838, Vol. II. p. 63; "Encycl. Met.," Vol. XII. p. 104; J. Lorimer, "Essay on Magnetism," London, 1795; Sir John Francis Davis, "The Chinese," Vol. III. p. xii, or "China," London, 1857, pp. 184–187; Whewell, "Hist. of Ind. Sc.," Vol. II. p. 46.

A.D. 1204–1220.—Jacobus de Vitry, Cardinal Bishop of Ptolemais, in Syria, one of the Crusaders, thus speaks of the compass in his



Guiot de Provins. "La Bible." In the Bibliothèque Nationale, Paris.

"Historiæ Hierosolimitanæ,"[1] cap. 89 and 91: "The Magnet [*diamant*, as shown under the B.C. 321 date] is found in the Indies. . . . It attracts iron through a secret virtue; after a needle has touched the loadstone, it always turns toward the North Star, which latter is as the world's axis and is immobile, while the other stars turn around it; that is why the compass is so useful to navigators, *valde necessarius navigantibus*."

REFERENCES.—Azuni, "Boussole," p. 140; Venanson, "Boussole," p. 77; Klaproth, pp. 14, 43–44; Poggendorff, Vol. II. p. 1184; Becquerel, "Elec. et Magn.," Vol. I. p. 70; Knight, "Mech. Dict.," Vol. II. p. 1397.

A.D. 1207.—Neckam (Alexander of), 1157–1217, Abbot of St. Mary's, alludes in his "De Utensilibus" to a needle carried on board ship, which, being placed upon a pivot and allowed to take its own position of repose, "showed mariners their course when the Polar Star is hidden." In another work, "De Naturis Rerum" (lib. ii. cap. 89), he writes: "Mariners at sea, when, through cloudy weather in the day, which hides the sun, or through the darkness of the night, they lose the knowledge of the quarter of the world to which they are sailing, touch a needle with a magnet which will turn around until, on its own motion ceasing, its point will be directed toward the North (Chappell, "Nature," No. 346, June 15, 1876; Thomas Wright, "Chronicles and Memoirs . . . Middle Ages," 1863).

REFERENCES.—"La Grande Encyclopédie," Vol. XXIV. p. 898; Hœfer, "Nouv. Biogr. Générale," Vol. XXXVII. p. 570.

A.D. 1235–1315.—Lully (Raymond) of Majorca (often confounded with Ramond Lull, who is the author of several alchemical books and of whose biography very little is known), was, by turns, a soldier, a poet, a monk, a knight, a missionary and a martyr, and is referred to by Humboldt as "the singularly ingenious and eccentric man, whose doctrines excited the enthusiasm of Giordano Bruno when a boy, and who was at once a philosophical systematizer and an analytical chemist, a skilful mariner and a successful propagator of Christianity."

During the year 1272 Lully published his "De Contemplatione," which was followed by "Fenix de las maravillas del orbe" in 1286, and by his "Arte de Naveguar" in 1295. In these he states that the seamen of his time employed instruments of measurement, sea charts and the magnetic needle (*tenian, los mareantes, instrumento, carta, compas y aguja*), and he describes the improvements made in

[1] The "Historiæ Hierosolimitanæ" relates all that passed in the kingdom of Jerusalem from 1177 to the siege of Ptolemais inclusively ("History of the Crusades," Joseph François Michaud, translated by W. Robson, Vol. I. p. 456).

the astrolabes (designed for the determination of time and of geographical latitudes by meridian altitudes and capable of being employed at sea) from the period that the astrolabium of the Majorcan pilots was in use.

The application of the astrolabe to navigation, Mr. Irving says ("Hist. of the Life . . . of Columbus," London, 1828, Vol. I. pp. 76–78), was "one of those timely events which seem to have some thing providential in them. It was immediately after this that Columbus proposed his voyage of discovery to the crown of Portugal."

Lully also confirms the fact that the Barcelonians employed atlases, astrolabes [1] and compasses long before Don Jaime Ferrer penetrated to the mouth of the Rio de Ouro, on the western coast of Africa, which was about fifty years after the date of the last-named work.

Incidentally it may be added that Lully, posing as an alchemist, is said to have in the presence of the English King, Edward I, converted iron into gold, which latter was coined into rose-nobles (Bergman, "Hist. of Chem."; Louis Figuier, "L'Alchimie et les Alchimistes," Paris, 1860, p. 148).

References.—For Lul. Raimon, or Raymundus, or Lullius (1235–1315), "Dict. of Philos. and Psych.," by J. M. Baldwin, New York, 1902, Vol. II. p. 32; Humboldt, "Cosmos," 1849, Vol. II. pp. 629–631, 670, and 1859, Vol. V. p. 55; Miller, "Hist. Phil. Ill.," London, 1849, Vol. II. p. 217; Whewell, "Hist. Ind. Sc.," 1859, Vol. I. p. 169; also his "Phil. of the Ind. Sc.," London, 1840, Vol. II. pp. 320–323; "Journal des Savants," 1896, pp. 342, 345–355; "Biogr. Génér.," article "Lulle"; Helfferich, "Raym. L.," Berlin, 1858; Nicolai Eymerici, "Direct Inq.," Rome, 1578; Bolton, "Ch. Hist. of Chem.," pp. 1000–1001; Ueberweg, "Hist. of Philos." (Morris' translation, 1885), Vol. I. pp. 457, 459; "Lives of Alchemystical Philosophers," by Arthur Edward Waite, London, 1888, pp. 68–88, in which is given, at pp. 276–306, an alpha-

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[1] The Astrolabe.—For descriptions of astrolabes used by the Arabs, see pp. 338–357 of "Matériaux . . . Sciences Mathém.," by L. A. Sedillot, Paris, 1845, and for plates showing the construction of the compass and other nautical instruments of his time, consult Crescentio (Bartolomeo), "Nautica Mediterranea," Rome, 1602.

The invention of the astrolabe is ascribed to Hipparchus, and Chaucer's description in 1391 is the first book treating of it in time and importance. In Chaucer's "Treatise on the Astrolabe," he declares his intention of making use of the calendars of the reverend clerks John Somer and Nicholas of Lynne. His reference here is to the Minorite astronomer John Somer—Semur—Somerarius—and to the Carmelite Nicholas, who was lecturer in theology at Oxford ("Dict. of Nat. Biog.," Vol. LIII. p. 219).

See the illustrated description of an astrolabe by S. A. Ionides, in "Geog. Journ." for Oct. 1904, pp. 411–417, accompanying references to other works treating of astrolabes; "Le Courrier du Livre," Quebec, 1899, Vol. III. p. 159, alluding to three works on the astrolabe of Samuel Champlin and Geoffrey Chaucer; "Canada," by J. G. Bourinot, London, 1897, p. 79, with cut of Champlin's lost astrolabe made in Paris during 1603; also the entry for Nicholas Bion to be found herein at A.D. 1702.

rerum oīm domitrix ad manc est: nescio qd cur=
ric: atq3 vt ꝓpius venit assistit · ac tenet̃ · et ꝯple
xu heret. Siderit in ob hoc alio nomine appellant
Quidā heradeon · Appellatus aūt est magnes ab
inuentore · vt autoꝛ est Nicandeꝛ ī india repertus ·
Nam et passim inuenit̃ · vt in hispania quoq3 · h⁹
genera quīq3 sotacus demōstrat · sc3 ethiopium
et magnesiacū e macedonia · Terciū in echio bo=
becie · Quartū circa troadem alexandrie · Quintū
in magnesia asie · Differētia ꝑma mas sit an fēia
ꝓxima ī coloꝛe · Na3 qui reperiunt̃ in magnesia et
macedonia · ruffi sūt et nigri · Boecius vero plus
habet ruffi coloꝛis: ꝙ nigri · Qui troade inuenit:
niger est ac feīei sexus: ideo sine viribus deteri
mus ī magnesia candidus neq3 attrahēs ferrum
similisq3 pumici · Ethiopicis laus sūma dat̃: pen=
dusq3 argento rependit̃ · ¶ Isidorus vbi supra ·
Magnes est lapis indicus: ab inuentore vocatus
Fuit aūt ī īdia ꝑmum repertus: clauis crepidaꝝ
baculiq3 cuspidi herēs · cū idē magnes armenta
pascerēt: postea passim est inuentus · Est aūt colo
re ferrugineus · Sed ꝓbat̃ cū ferro adiectus fe=
cerit raptū: vnde et eū vulgus ferrū viuū appel=
lat: liquorē quoq3 vitri (vt ferꝝ) trahere credit̃
Oīs autē magnes tanto melioꝛ est · quāto magis
ceruleus · ¶ Arestotiles in libro de lapidibus ·
Lapis magnes ferꝝ trahit: et ferrū obediens est
huic lapidi ꝑ virtutem occultā: que inest illi · ipm
mouet ad se ꝑ oīa corꝑa solida: sicut ꝑ aera · & v=
no quidē ipsius angulo trahit ferrū · ex opposito
aūt angulo fugat ipm · Angulus qdē eius: cui v̇=
tus est attrahēdi ferrū: est ad zaron · i · septētriō3
Angulus aūt oppositus ad afon · i · meridiē · Itaq3
ꝓprietatē habet magnes: ꝙ si aꝓximes ei ferru3
ad angulū ipsius: qui zaron · i · septētrionē respic̃:
ad septētrionē se cōuertit Si vero ad angulū op
positū ferrū admoueris: ad afō · i · meridiē se mo=
uebit · Q; si huic ferro ferrū aliud adꝓximaue=
ris ipm de magnete ad se trahit · hoc et lapis ada
mas facit: naturamq3 condemnat magnetis ·
xx · ¶ De miraculo magnetis in ferri attracti
one · ¶ Augustinus de ciuitate dei · xxi · libro ·

MAgnetē lapidē nouimus esse mirabilem
ferri raptorē · Quod cū ꝑmū vidi vehe
menter exhoꝛrui · Quippe cernebā a la=
pide ferreū anulū raptū atq3 suspensū · deniq3 tā
ꝙ ferro quod rapuerat: vim suā dedisset omunē
q3 fecisset · Idē anulus alteri admotus est: eundē
q3 suspendit · Sic accessit et tercius et quartus:
Iāq3 sibi ꝑ mutua circulis nexis: non īplicatoꝛu3
intrinsecus: sed adherentiū extrinsecus: quasi ca
thena pepēderat anuloꝝ · Quis istam vim lapi=
dis nō stuperet: que illi non solū inerat: sed etia3
ꝑ tot suspēsa trāsibat · et inuisibilibus ea vīculis
subligabat · Sed multo mirabili⁹ est: quod a fr̃e
meo et coepiscopo seuero millenitano de isto la=
pide cōperi · Seipm nāq3 vidisse narrauit: quēad
modum lucanarius quondā comes africe: cū apd̃
eū ꝯuiuaret̃: epus eūdē ꝓtulerit lapidē: et eum
tenuerit sub argento: ferrūq3 suꝑ argentū posu
erit Deīde sic subt̃ mouebat manū: q lapidē tene
bat: Ita ferꝝ dēsuꝑ mouebat̃ · aūt3 argēto medio ni
chilq3 patiente cōcitatissimo cursu ac recursu in=
fra lapis ab hoīe: supra ferrū rapiebat̃ a lapide ·
dixi ꝙ ipe cōspexi: dixi ꝙ ab aliis audiui: cui tan
ꝙ ipe viderim credidi · Quid etiā de isto magne=
te legerī dicā quādo iuxta eū adamas pōit̃: ferꝝ
nō rapit · Et si iā rapuerat: vbi ei aꝓpinquauerit
mox remittit · Ex hoc aūt ꝙ magnes ferrū attra=
hit: tam mirifica fiūt arte mechanica: vt ea q ne=
sciant opinentur esse diuina · Nōne factum est ꝙ
in quodam tēplo lapidibus magnetibus in solo
& in camera ꝓportione magnitudinis positis: si=
mulacrū ferreū aeris illius medio inter vtrūq3 la
pidem quasi numīs potestate penderet · quale ali
quid etiam ī lucerna veneris de lapide abesto ab
artifice fieri potuit · quod gentiles mirarent̃ · In
quo lapide mirꝝ est: ꝙ cū ignem nullū habeat ꝓ=
priū: accepto tamē: sic ardet alieno: vt extingui
nō possit · sic ergo et in magnete: quod nescio q ī
sensibili soꝛbitione stipulam non mouet: ferꝝ &
rapit · xxi · ¶ De virtute ipius in me=
dicina · ¶ Dyascorides ·

MAgnes gignit̃ circa litus occeani: apud
trogoditas magnas habēs virtutes · &
vel ut spiritū in attrahendo ferꝝ: fures
intrantes domū vt ꝑciosa deripiāt: intra quatu=
oꝛ angulos domus carbones ardētes ponunt: et
lapidē minute ꝑcisū suꝑmittūt · sicq3 mentes & o
culos eoꝝ qui assunt: auertūt: vt timoꝛe fugiāt:
putantes suꝑ se ruere domū · Habet aūt vires ꝑ
gatoꝛias · et ob hoc ydropicis cū mulsa dat⁹: groſ
situdinē deducit: & oīes humoꝛes ꝑ ventrē mi=
strat · Tritus etiā et suꝑaspersus ꝯbusta sanat ·
¶ Cōstantinus in libro graduū: Magnes in ripa
maris indie reperit̃ · cuius natura calida est et sic
ca in tercio gradu · Dicit etiā galienus in libro
de lapidibus: ꝙ naute nauē ferreos clauos habē
tem: illuc nō audent ducere · Nec vllū ferri arti=
ficiū in ea habere · Naui em̃ illis montanis aꝓpin=
quante: oēs claui et qdquid ferri ī ea habet̃ a mō
tanis attrahunt̃ sua ꝓprietate · Hic lapis potui
datus: optimū est ei qui de ferro toxicato vulne
ratus est · Et eis qui infirmant̃ ꝺ ferrugine catha
plasmatibus vel emplastris cōmixtus: valet ad sa
gitta3 vel gladiū extrahendū de vulnere · Ruffus
dixit eundē lapidē melācolicos ꝯfortare: timoꝛe3
& suspicionē eis auferre ¶ Platearius vbi suꝑ ·
Magnes est calidus et siccus in tercio gradu: va
let precipue vulneratis: quia ferꝝ attrahit · pul=
uis etiā eius datus in succo feniculi: valet cōtra
ydropisim et splenē et alopeciā · Attrahit em̃ fle
gma et melancoliā · ¶ Auicēna vbi suꝑ · Magnes
cū adurit̃ fit emathites: et virtus eius sicut vir=
tus illius · Melius est niger ībibitus rubedie · pu
rus aūt abstersiuus & mūdificatiuus · ¶ Plini⁹
vbi supra · In quadā ethiopie regione inuenitur
emathites: magnes sanguinei coloꝛis: sanguinem
q3 reddens: si terat̃ · sed et etiā crocū · At in attra=
hendo ferꝝ: non est natura eadē emathiti q ma=
gneti · Oēs aūt hi medicamētis oculoꝝ ad suam
quoq3 poꝛtionē ꝯsunt: maximeq3 epyfora sistūt
sanāt et adusta cremati ac triti xxij ·
¶ De gagate · ¶ Isidorus vbi supra ·

GAgates ꝑmū in sicilia inuentus est: Ga=
gatis fluminis fluoꝛe reiiectus: vnd̃ et
noīatus · licet in britania sit plurimus ·
Est autē niger planus leuis · & ardēs igni admo
tus fictilia in eo scripta non delent̃ · Incens⁹ ser=
pentes fugat: demoniacos ꝓdit virginitatē deꝑ
hendit · Mirꝝ ꝙ aqua accendit̃ oleo extinguitur ·
Plinius vbi supra · Gagates lapis nomen habet

Vincent de Beauvais. "Speculum Naturale."
Page taken from the 1473 copy, now in the Bibliothèque, Ste. Geneviève, Paris.

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betical catalogue of all works on Hermetic Philosophy and Alchemy; Humboldt, "Examen Critique," Paris, 1836, Vol. I. pp. 7, 283.

For the Dominican Giordano (Jordano) Bruno, see "The Course of the History of Modern Philosophy," by Victor Cousin, New York, 1872, Vol. II. pp. 56–58; "English Cycl." (Biography), Vol. I. p. 979; Libri, "Hist. des Sc. Mathém.," Paris, 1838, Vol. I. p. 141; "La Grande Encycl.," Vol. VIII. pp. 258–259, reviewed in the "London Athenæum," Nov. 28, 1903, p. 711.

A.D. 1250.—Vincent de Beauvais, another Crusader, writes his "Mirror of Nature" ("Bibliotheca Mundi, Speculum Majus, Speculum Triplex") for St. Louis and his consort, Marguerite de Provence, and speaks therein of the polarity of the needle ("Speculi Naturalis," Vol. II. lib. ix. cap. 19). He cites Aristotle as having written a book, "De Lapide," containing a notice of the magnet's use in navigation, but none of Aristotle's known works appear to have the passage given. Cabæus and others rather judge that book to be the work of some Arabic writer (Thomas Creech, "Lucretius"). Libri, however, says that a translation or *abrégé* of the MS. of "De Lapide" is at the Paris Library—MSS. Arabes, No. 402 ("Hist. des sc. Mathém.," Vol. I. p. 101).

Le Sieur Petrus Peregrinus de Maricourt (see A.D. 1269) alludes clearly to the polarity of the needle in an epistle, "Ad Sigerum de Foucaucourt—Fontancourt—militem de Magnete," written toward the end of the thirteenth century, and the magnet is, at about the same period, referred to in the following lines of the minstrel Gauthier d'Espinois, contemporary of the Count of Champagne, Thibaud VI, who lived before the middle of the thirteenth century ("Hist. Lit. de la France," 1856, Vol. XXIII—chansonniers—pp. 576, 831):

> "Tout autresi (ainsi) comme l'aimant déçoit (détourne)
> L'aiguilette par force de vertu
> A ma dame tot le mont (monde) retennue
> Qui sa beauté connoit et aperçoit."

Vincent de Beauvais applies the terms *zohron* and *aphron* (not *afon*) to the south and north ends of the needle, and Mr. J. Klaproth ("Lettre à M. de Humboldt sur l'invention de la Boussole," Paris, 1834, pp. 49–51), says these words are Arabian, notwithstanding assertions made to the contrary by Martinus Lipenius in his "Navigatio Salomonis Ophiritica Illustrata," 1660, cap. v. sec. 3, as well as by many others who have written upon the compass.

References.—Sonnini, in Buffon, "Minéraux," VIII. p. 76; Humboldt, "Cosmos," 1859–1860, Vol. II. pp. 253–254, and Vol. V. p. 54; Azuni, "Boussole," pp. 41, 42, and 44; Klaproth, p. 13; Miller, "History Philosophically Illustrated," London, 1849, Vol. I. p. 179, note. "Simonis Maioli . . . Dies Caniculares, seu Colloqui," XXIII. 1597, p. 783; Dr. F. Ueberweg, "Hist. of Phil." (Morris' translation, 1885), Vol. I. pp. 433, 435; "Journal des Savants" for Feb.–Mar. 1892; "Vincenti Bellov. Speculi Naturalis," Vol. II. lib. ix. cap. 19.

It may be added that the "Mirror of Nature" [1] is one of the four pretentious works which, however popular they may at any time have been and however powerfully they may have influenced the age in which they were written, do not, says Humboldt, fulfil by their contents the promise of their titles. The other three are the "Opus Majus" of Roger Bacon, the "Liber Cosmographicus" (Physical Geography) of Albertus Magnus, and the "Imago Mundi" (Picture of the World) of Cardinal Petrus de Alliaco—Pedro de Helico—Pierre d'Ailly. (For the celebrated French theologian Pierre d'Ailly (1350-1420), Chancellor of the Paris University, see "Histoire de l'Astronomie," J. F. C. Hœfer, Paris 1873, p. 290; "Paris et ses historiens," Le Roux de Lincy et L. M. Tisserand, Paris, 1867, p. 402 (etched portrait); "New Int. Encycl.," New York, 1902, Vol. I. p. 231; "La Grande Encycl.," Vol. I. pp. 952–954; also works relating to him by Aubrelicque, Compiègne, 1869, by Arthur Dinaux, Cambrai, 1824, and by Geo. Pameyer, Strasbourg, 1840.) The last-named work by Pierre d'Ailly was the chief authority at the time and exercised a greater influence on the discovery of America than did the correspondence with the learned Florentine Toscanelli (Humboldt, "Cosmos," 1849, Vol. II. p. 621; "La lettre et la carte de Toscanelli," par Henri Vignaud, Paris, 1901, or "Toscanelli et Christophe Colomb" in the "Annales de Géographie," No. 56, 11^{e} année, Mars 15, 1902, pp. 97–110; "Toscanelli in der älteren und neuren Columbus literatur," E. Geleich Mitteil. Wien, Vol. XXXVI. 10, 1893).

Two of the above-named works partake of the encyclopædic, and in this class likewise properly enter the twenty books "De Rerum Natura" of Thomas Cantapratensis of Louvain (1230), the "Book of Nature," by Conrad Van Meygenberg of Ratisbon (1349), and the great "Margarita Philosophica," or "Circle of the Sciences,"

[1] Vincent de Beauvais desired to facilitate the pursuit of learning by collecting into one large work everything useful to be known in art, history, natural science and philosophy, "so that the great edifice of science should be once more presented with all its halls and porticos forming one harmonious whole, *domed* over, if we may so express ourselves, with theology and surmounted by the Cross" ("Eccl. History," Rohrbacher, Vol. XVIII. p. 444, quoted at pp. 86 and 89 of "Christian Schools and Scholars," London, 1867). His "Speculum Majus," of which the most trustworthy edition was that published at Strasbourg in ten large folio volumes during 1473, consisted of three parts: "Speculum Naturale," 32 books and 3718 chapters; "Speculum Doctrinale," 17 books and 2374 chapters; "Speculum Historiale," 31 books and 3793 chapters, a total of 80 books and 9885 chapters ("Encycl. Britan.," ninth ed., Vol. XXIV. p. 235; "Paris et ses historiens," Paris, 1867, p. 100, note, indicating that, according to Fabricius, the "Speculum Naturale" mentions as many as 350 different names of Arabian, Greek and Latin authors). The influence of the mediæval encyclopædias of Vincent de Beauvais, Brunetto Latini and Bartholomew Anglicus on Western Literature of the fourteenth and fifteenth centuries is presented in Liliencron's "Festrede," München, 1876 (J. E. Sandys, "Classical Scholarship," 1903, p. 558).

of Father Gregorius Reisch (1486). (See the different entries concerning the last-named work at pp. 663–664 of Libri's Catalogue, Vol. II, for 1861.) One more work bears title "Picture of the World"—"l'Image du Monde"—written by Gautier de Metz, a French poet of the thirteenth century, on the lines of still another encyclopædic "Imago Mundi," by Honorius d'Autun (Neubauer, "Traductions historiques de l'Image du Monde," 1876, p. 129; Haase, likewise Fritsche, "Untersuch . . . der Image du Monde," 1879 and 1880; Fant, "l'Image du Monde, étudié dans ses diverses rédactions françaises," Upsal, 1886. Chas. Bossut, in his "Hist. Générale des Mathém.," Paris, 1810, Vol. I. p. 229, also mentions an encyclopædic "Mirroir du Monde," in Turkish *Gian Numah*; "The Final Philosophy," Chas. W. Shields, New York, 1877, p. 133).

A.D. 1254.—Albertus Magnus, of the family of the Counts of Bollstädt, one of the most prominent philosophers and theologians of the Middle Ages, likewise alludes to the book "De Lapide" already referred to at A.D. 1250, and to the Arabic terms *zohron* and *aphron*, giving to these words, however, a wrong interpretation.[1]

Albertus Magnus (1193–1280) was justly styled *Doctor Universalis*, for, from the time he entered the Order of the Dominican Friars in 1221, as well as throughout his teachings, mainly at Bologna, Strasburg, Freiburg and Cologne, he displayed an intimate acquaintance with almost all branches of the natural sciences. He was especially well versed in philosophy, astronomy and mathematics—*in rebus magicis expertus fuit*—and was justly considered by many as the most erudite philosopher of his generation; an encomium of the very rarest kind, when such rivals as Alexander of Hales and Thomas Aquinas could dispute the palm with him. Natural science, says Humboldt ("Cosmos," 1860, Vol. II. pp. 243–245), was intimately associated with medicine and philosophy among the learned Arabs, and, in the Christian Middle Ages, with theological polemics. The latter, from their tendency to assert an exclusive influence, repressed empirical inquiry into the departments of physics, organic morphology, and also astronomy, the last being, for the most part, closely allied to astrology. The study of the comprehensive works of Aristotle, introduced by Arabs and by

[1] In his "De Mineralibus" (Lyons ed. 1651, Treat. III. lib. ii. cap. 6, p. 243), Albertus says: "One angle . . . is to the *zohron* (north) . . . but another angle of the magnet opposite to it attracts to the *aphron* (south)." Cardan ("De Subtilitate," Lugduni, 1663); Salmanazar (Book II. "of the Egyptian Hermitus, 19 stars, and 15 stones, and 15 herbs, and 15 figures": "on one side the magnet attracts iron, on the other side repels it); Pietro d' Abano ("Conciliator Differentiarum," Mantuæ, 1472, Diff. 51, p. 104, or the 1520 Venice edition, p. 73: "know that a magnet is discovered which attracts iron on one side and repels it on the other").

Jewish Rabbis, had tended to lead to a philosophical fusion of all branches of study (Jourdain, "Sur les traductions d'Aristotle," p. 256; Michael Sachs, "Die Religiöse Poesie der Juden in Spanien," 1845, s. 180–200), and hence Ibn-Sina (Avicenna), Ibn-Roschd (Averroës), Albertus Magnus and Roger Bacon passed for the representatives of all the knowledge of their time. The fame which in the Middle Ages surrounded the names of these four great men was proportionate to the general diffusion of this opinion of their endowments.

Albertus was the first scholastic who systematically reproduced the philosophy of Aristotle with reference to the Arabian commentators and who remodelled it to meet the requirements of ecclesiastical dogma. The cause of the new development of scholasticism in the thirteenth century was the translation, for the first time, into Latin of the complete works of Aristotle, which latter only came to the knowledge of the scholastics (1210–1225) through the agency of Arabian philosophy. The leading Arabian philosophers were Avicenna, Averroës and Avempace, whilst, in the new movement, Albertus Magnus, St. Thomas Aquinas and Joannes Duns Scotus represented the culmination of scholastic thought and its consolidation into a system.[1]

Albertus, according to Humboldt, must be mentioned as an independent investigator in the domain of analytic chemistry, improving as he did the practical manipulation of ores, and having actually enlarged the insight of men into the general mode of action of the chemical forces of nature. His "Liber Cosmographicus" is a singularly able presentment of physical geography. He also wrote very extensively upon plant-life, and is the author of commentaries upon practically all the physical works of the Stagirite, although in the commentary on Aristotle's "Historia Animalium" he is said to have closely followed the Latin translation of Michael Scotus from the Arabic. Albertus doubtless owes the praise conferred upon him by Dante less to himself than to his beloved pupil Aquinas, who accompanied him from Cologne to Paris in 1245, and returned with him to Germany in 1248.

[1] Albertus was the first schoolman who lectured on the Stagirite, and who in his unbounded range of knowledge comprehends the whole metaphysical, moral, physical, as well as logical system of Aristotle ("History of Latin Christianity," by the Rev. H. H. Milman, London, 1857, Vol. VI. pp. 270, 277). The first knowledge of the Aristotelian philosophy in the Middle Ages was acquired by translators of Aristotle's works out of the Arabic. The Arabian commentators were considered the most skilful and authentic guides in the study of his system ("Hist. of the Reign of Charles V," Robertson and Prescott, Philad., 1883, Vol. I. p. 308; Conring, "Antiq. Acad.," Diss. III. p. 95, Supplem. p. 241; Murat, "Antiq. Ital.," Vol. III. p. 392; "Aristotle and the Arabs," at pp. 257–268 of "Classical Studies in Honour of Hy. Drissler," New York, 1894; Humboldt, "Cosmos," 1860, Vol. II. pp. 215–216).

"Questi, che m' è a destra più vicino,
Frate e maestro fummi; ed' esse Alberto
E' di Cologna, ed io Thomas d' Aquino."
"Il Paradiso," X. 97–99.

Gilbert refers to Albertus in "De Magnete," Book I. chaps. i. and vi., also in Book II. chap. xxxviii.

References.—"Albert the Great," by Dr. Joachim Sighart, translated by Rev. Fr. J. A. Dixon, London, 1876; "Journal des Savants" for May 1848 ("D'un ouvrage inédit de Roger Bacon": Albertus is called *Magnus in magia naturali, major in philosophia, maximus in theologia;* Tritheim, "Annales Hirsaug.," Vol. I. p. 592); for May 1851, pp. 284–298 *passim;* for Nov. and Dec. 1884; for June 1891 ("Traditions . . . du Moyen Age"), for Feb. 1892 ("Traductions des ouvrages alchimiques . . . arabes; l'alchimie dans Albert le Grand," pp. 126–128), as well as for March 1892; "Histoire des Sciences," par. F. M. L. Maupied, Paris, 1847 (Albert le Grand), Vol. II. pp. 1–95; Barthol. Glanvilla, "Liber. de Proprietatibus Rerum," Book VII; Pellechet, "Cat. Gen. des Incunables," 1897, pp. 57–81; Bolton, "Chronol. Hist. of Chemistry," 1897, p. 947; "The Great Schoolmen of the Middle Ages," by W. J. Townsend, London, 1881, Chap. X. pp. 165–173; "Siger de Brabant et l'Averroïsme Latin au xiii[e] siècle," par. Pierre Maudonnet, Fribourg, 1899, pp. li–lii notes *passim;* Walton and Cotton, "Complete Angler," New York and London, 1847, Pt. I. p. 62; "New Int. Encycl.," New York, 1902, Vol. I. p. 279; "Aristotle and the Arabs," by Wm. M. Sloane, pp. 257–268 of "Classical Studies in Honour of Henry Drissler," New York, 1894; Sonnini, Buffon, "Minéraux," VIII. p. 76; Enfield, "History of Philosophy," Book VII. chap iii.; Humboldt, "Cosmos," 1849, Vol. II. pp. 617–619; Quétif and Echard, "Scriptor. Ord. Predicat," Vol. I. p. 171; Brande, "Manual," 1848, Vol. I. p. 8; Dr. Friedrich Ueberweg, "History of Philosophy," tr. by Geo. S. Morris, New York, 1885, Vol. I. pp. 436–440; J. B. Hauréau, "La Philos. Scholas.," Paris, 1850, Vol. II. pp. 1–103; Dr. W. Windelband, "History of Philosophy," auth. tr. by Jas. H. Tufts, New York, 1853, pp. 311, 313; "Dict. Hist. de la Médecine," N. F. J. Eloy, Mons, 1778, Vol. I. pp. 63–65; "Christian Schools and Scholars," Augusta Th. Drane, London, 1867, pp. 69, etc.

Of authors prominently cited by Albertus Magnus, or alluded to in the foregoing, the following accounts are given:

Alfarabius—Alpharabius—Abn Nasr Muhammed . . . al Farabi—(A.D. 870–950), celebrated Arabian philosopher, native of Turkestan, one of whose most important works, "Liber de scientiis . . ." is an encyclopædia, giving in five chapters a classification of all known sciences. It is said he could speak in as many as seventy languages (J. C. L. S. de Sismondi, "Historical View of the Literature of the South of Europe," London, 1846, Vol. I. p. 65). He was a most zealous student of Aristotle, and is one of the authors (Aristotle, Avicenna and Al-gazel being the others) from whom David the Jew compiled his work "De Causis." Of the latter, Albertus gives a long description, and it is likewise cited both by Thomas Aquinas and Bacon, "Opus Majus," J. H. Bridges, Oxford, 1897,

Vol. I. pp. 100–101, who quotes: Jourdain, pp. 112, 138–145, 184–185, and Wüstenfeld, "Geschichte," Göttingen, 1840.

REFERENCES.—Larousse, "Dict. Univ.," Vol. I. p. 195; "Biog. Gen.," Vol. I. pp. 951–952 and the references therein given; "New Int. Encycl.," New York, 1902, Vol. I. pp. 329–330; M. Stenischneider, "Al-Farabi," St. Petersb., 1869; Friedrich Dieterici, "Al-Farabi's Philosophische Abhandlungen," Leyden, 1890, and his "Die Philosophie der Araber," Leyden, 1892, 1895; Dr. Friedrich Ueberweg, "History of Philosophy," tr. by Geo. S. Morris, New York, 1885, Vol. I. pp. 407, 411–412.

Al-gazel—Al-Ghazzali—(1058–1111), another prominent Arabian philosopher, who was for a long time professor of theology in the Bagdad University, and became the ruler of the Sufis or Mystics, in whose behalf he travelled extensively.[1]

The biography in "La Grande Encyclopédie," Vol. XVIII. pp. 899–900, gives a full account of his most important works and several valuable references, his principal book being "The Destruction of the Philosophers," which called forth a reply in one of the two most important works of Averroës, entitled "The Destruction of Destruction."

Tholuck says: "If ever a man hath deserved the name, Ghazzali was truly a divine, and he may justly be placed on a level with Origen [Fr. Dietericii, "Die Philosophie der Araber," Leipzig, 1876, pp. 28–31], so remarkable was he for learning and ingenuity, and gifted with such a rare faculty for the skilful and worthy exposition of doctrine."

REFERENCES.—"Encycl. Britann.," ninth ed., Vol. I. p. 510; "New Int. Encycl.," Vol. I. p. 337; "The Alchemy of Happiness," by Mohammed Al-Ghazzali, tr. of Henry Guy Homes, Albany, 1873, pp. 6–7, also Dr. Friedrich Ueberweg, "History of Philosophy," tr. by Geo. S. Morris, New York, 1885, Vol. I. pp. 407 and 413–414.

Alexander of Hales, so called because he made his studies at the Monastery of Hales in Gloucestershire (*d.* 1245), called "Doctor Doctorum" or "Doctor Irrefragabilis," also "Theologorum Monarcha," was a celebrated English theologian. He became a noted professor of philosophy and then a lecturer among the Franciscans, being succeeded in turn by his pupils, John of Rochelle (who died in 1271) and John Fidanza, better

[1] See "Omar Khayyám and his position in the History of Sufism," to be found at end of the singularly attractive volume entitled "Sufi Interpretations . . ." by C. H. A. Bjerregaard, New York, 1902. For an account of Omar Khayyám—Kheyyám (died in 1123), who was a very distinguished Persian philosopher, mathematician, poet and astronomer, also Director of the Bagdad Observatory, consult the ninth ed. of the "Encycl. Britann.," Vol. XVII. pp. 771–772; "La Grande Encycl.," Vol. XXV. pp. 372–373; "The Universal Cyclopædia," Chas. Kendall Adams, New York, 1900, Vol. VIII. p. 588.

known as Bonaventura (1221–1274). He was the first scholastic acquainted with the whole of the Aristotelian works and with the Arabian commentaries upon them. The only authentic work of his is the ponderous "Summa Universæ Theologiæ" (best edition, Venice, 1576), much of the substance and even the text of which is said to be found in the "Summa" of Aquinas and in the "Speculum Morale" of Vincent de Beauvais.

References.—"Dict. of Nat. Biog.," London, 1885, Vol. I. p. 271; "La Grande Encycl.," Vol. II. p. 121; Fleury, "Hist. Eccles.," Vol. XX; Du Boulay, "Hist. de l'univ. de Paris," Vol. I.; Stoeckl, "Geschichte d. Phil. d. Mittelalters," 1865, Vol. II. pp. 317–326; "Chambers's Encycl.," 1888, Vol. I. p. 148; Ninth "Encycl. Britann.," Vol. XXI. p. 427; "Dict. of Philos. and Psychol.," by J. M. Baldwin, New York, 1901; Vol. I. pp. 30, 124; Wadding, "Annales Ord. Min."; "New Int. Encycl.," New York, 1902, Vol. I. pp. 321–322; Fabricius, "Bibl. Lat. mediæ et inf. ætat.," Vol. I. p. 1; "Biog. Gén.," Vol. I. pp. 923–927; J. B. Hauréau, "Hist. de la Philos. Scholastique," 1880, Vol. I. part ii. pp. 131–141, or the 1850 Paris ed., Vol. I. p. 418; Dr. Friedrich Ueberweg, "History of Philosophy," tr. by Geo. S. Morris, New York, 1885, Vol. I. pp. 433–434; Thos. Fuller, "Church History of Britain," London, 1837, Vol. I. pp. 398–402.

Avempace—Abn Bekr Muhammed Ibn Yahga, Arabic philosopher, physician and poet (*d.* 1138), introduced the peripatetic philosophy into Andalusia, and wrote commentaries on Aristotle, in addition to a book, "Conduct of the Individual," alluded to by Averroës, likewise several works upon medicine and music.

References.—"The History of Philosophy" of Dr. Friedrich Ueberweg, tr. by Geo. S. Morris, New York, 1885, Vol. I. p. 414 (Munk, "Mélanges de Philosophie," pp. 383–410); "New Int. Encycl.," New York, 1902, Vol. II. p. 281; Brockelmann, "Geschichte der Arabischen Litteratur"; James Gow, "A Short History of Greek Mathematics," Oxford, 1884, pp. 203–205 for Arabic learning in Spain.

Averroës—Muhammed Ibn Ahmed Ibn-Roschd, "the commentator," "the last great thinker of the Moslem world in the West" (1120–1198), was an illustrious Moorish philosopher and physician best known by his commentaries and paraphrases upon Aristotle. It is said Averroës was recommended to the Calif as the fittest person to expound the works of Aristotle and make them accessible to all ("History of Classical Scholarship," J. E. Sandys, Cambridge, 1903, p. 541).

References.—Renan, "Averroës et l'Averroïsme," Paris, 1852; "Dict. of Philos. and Psychology," by J. M. Baldwin, New York, 1901, p. 96; "Journal des Savants" for Feb. 1892, pp. 118–126 *passim*; Antonii, "Bibl. Hisp. Vetus," Vol. II. pp. 240–248; Wüstenfeld, "Geschichte d' Arab. A. V. N.," 1840; "Engl. Cycl.,"

Vol. I. pp. 448–449; Eloy, "Dict. Hist. de la Médecine," Vol. I. pp. 220–221; Dr. Friedrich Ueberweg, "History of Philosophy," tr. by Geo. S. Morris, New York, 1885, Vol. I. pp. 407–408, 415–417; Dr. W. Windelband, "History of Philosophy," auth. tr. by Jas. H. Tufts, New York, 1893, pp. 317, 338; "Dictionnaire des Sciences Philosophiques," par une société de savants, Paris, 1852, Vol. III. pp. 157–172.

"Euclide geometra e Tolommeo,
Ippocrate, Avicenna, e Galieno
Averrois che 'l gran comento feo."
(Dante, "Divina Commedia," Inferno, Canto IV.)

Augusta Th. Drane places Averroës at the head of all Arabic interpreters of Aristotle, and incidentally says it would be hard to determine his religion, for he scoffed alike at Christianity, Judaism and Mahometanism.

Avicenna—Abohalis, Ibn Sina, Al Rayis or "the chief"—(980–1037), "the greatest thinker of the Moslem world in the East," a native of Aschena, near Bokhara, was the most celebrated physician of his day. In the "Journal des Savants" for March 1892, "l'Alchimie d'Avicenne" is very extensively treated of at pp. 179–189, and Avicenna is said ("Journal des Savants" for February 1892, pp. 118–128) to be the alchemist most frequently alluded to in the "Speculum Naturale" of Vincent de Beauvais. His writings were so highly esteemed that the Sultan of Egypt ordered them to be translated by the celebrated Jewish Rabbi, Maimonides—Moses Ben Maimon—(born at Cordova, in Spain, about A.D. 1132).

References.—Casiri, "Bibl. Arab. Hispan.," Vol. I. p. 268; Hottinger, "Bibl. Quadrip.," 1664, pp. 256, 261; "Dict. des Sciences Philosophiques," Paris, 1852, Vol. III. pp. 172–178; S. Klein, "Dissertatio," 1846; Houzeau et Lancaster, "Bibl. Gen.," Vol. I. pt. i. pp. 469–470; "The Edinburgh Encycl.," 1830, Vol. III. p. 107; "Engl. Cycl.," Vol. I. pp. 449–450; Gilbert, "De Magnete," Book I. chaps. i., viii., xv. and Book II. chap. ii.; Eloy, "Dict. Hist. de la Médecine," Vol. I. pp. 223–227; Dr. Friedrich Ueberweg, "History of Philosophy," tr. by Geo. S. Morris, New York, 1885, Vol. I. pp. 407, 412–413; Dr. W. Windelband, "History of Philosophy," auth. tr. by Jas. H. Tufts, New York, 1893, p. 317; "New Gen. Biog. Dict.," London, 1850, Vol. XII. p. 43; "Dict. of Philosophy and Psychology," by J. M. Baldwin, New York, 1901, Vol. I. p. 97; "Lectures on Metaphysics and Logic," by Sir Wm. Hamilton, London, 1860, Vol. II. pp. 167, 171; "Historical View of the Literature of the South of Europe," by J. C. L. S. de Sismondi, London, 1846, Vol. I.

Duns Scotus, John, "Doctor Subtilis" (born about 1270, died in 1308), a very prominent schoolman, who was educated at Oxford, entered the Order of St. Francis, and became one of the great founders of scholastic thought. But little is known as to his origin, except that a monument, erected to his memory

at Cologne during the year 1533, bears the following: "*Scotia me genuit, Anglia me suscepit, Gallia me docuit, Colonia* (*Germania*) *me tenet.*"

As shown by Luc. Wadding in his "J. Duns-Scoti Opera," twelve volumes, published at Lyons in 1639, his works are quite numerous, the most important consisting of questions and commentaries on the writings of Aristotle and on the "Sentences" of Peter Lombard.

Joannes Duns Scotus is very frequently referred to by Dr. W. Windelband ("History of Philosophy," auth. tr. by Jas. H. Tufts, New York, 1893, pp. 311, 314–315, 321–326, 344), and is mentioned as "the acutest and deepest thinker of the Christian Middle Ages, who brought the germs of the philosophy of the will, contained in Augustine's system, to their first important development, and so from the metaphysical side gave the impulse for a complete change in the direction of philosophical thought."

References.—"Dict. of Nat. Biog.," London, 1888, Vol. XVI. pp. 216–220; Ritter's "Geschichte der Philosophie"; Dr. Friedrich Ueberweg, "History of Philosophy," tr. by Geo. S. Morris, New York, 1885, Vol. I. pp. 452–457; Larousse, "Dict. Univ.," Vol. VI. p. 1398, containing an extensive list of references; Alfred Weber, "History of Philosophy," New York, 1896, pp. 246–252 (tr. of Frank Thilly); "Biog. Gén.," Vol. XV. pp. 256–257; "La Grande Encycl.," Vol. XV. pp. 71–72; Pluanski, "Thèse sur Duns Scot," Paris, 1887; "The Great Schoolmen of the Middle Ages," W. J. Townsend, London, 1881, "Duns Scotus," Chap. XV.; J. B. Hauréau, "La Philosophie Scholastique," Paris, 1850, Vol. II. pp. 307–417. Consult also the biographies written by Ferchius, Berti, Caveili and Veglensis, and, for a complete exposition of his system, C. Werner, "Die Scholastik des Späteren Mittelalters," Vienna, 1881, Vol. I; "Illustrations of the History of Medieval Thought," by R. L. Poole, London, 1884.

A.D. 1254.—Bacon (Roger), "the most remarkable man in the most remarkable century of the Middle Ages" (E. H. Plumptre, 1866), sometimes called Friar Bacon (1214–1294), a Franciscan monk of Ilchester, who devoted himself to the study of science at Oxford and Paris and "whose deep penetration into the mysteries of nature justly entitled him to the appellation of "The Wonderful Doctor," treats of the magnet and of its properties at pp. 383–384 of his "Opus Minus" (J. S. Brewer, "Fr. R. Bacon," London, 1859), and dwells upon the loadstone as a *miraculum in parte notum.*

Bacon is also the author of many other works, the most important of which are his "Opus Majus" and "Opus Tertium" (first published in English respectively in 1733 and 1859), the last named having been originally written out for Pope Clement IV and intended to serve as a preamble to the "Opus Minus" and "Opus Majus,"

although it was later than either in the date of its composition (Brewer, *op. cit.* p. xliv). Leland has said that it is easier to collect the leaves of the Sybil than the titles of all of Bacon's works. At pp. 218–222, Vol. III. of the ninth edition "Encyclopædia Britannica" will be found a synopsis of the six parts into which Jebb divided the "Opus Majus" (pronounced by Whewell "at once the Encyclopædia and the Organum of the thirteenth century"), and likewise an account of his other works, besides numerous references to leading authorities.

In the "Opus Tertium," the last of the series of three which, it is said, were all completed in about eighteen months, he speaks more than once of A.D. 1267 as being the then current year. This happens to be but two years prior to the date of the epistle of Pierre Pélerin de Maricourt, the great experimentalist (Petrus Peregrinus), whom he commends (p. lxxv) in the following words: "For there are only two perfect mathematicians, Master John of London [1] and Master Peter of Maricourt, the Picard . . . who is worth more than any of them . . . of whom I have fully written in my 'Opus Minus' and of whom I shall write more in its proper place." Of this Master Peter, whom he calls one of his most illustrious pupils, he further says that, being "struck with the genius that dawned in his countenance," he took him under his protection from his fifteenth year and instructed him so carefully that he outstripped all of his contemporaries both at Oxford and at Paris. "There is no one," adds he, "who knows so much of the root of Philosophy . . ." and one who, "through experiment, gains such knowledge of things natural, medical, chemical; indeed, of everything in the heavens or earth."

Gilbert states ("De Magnete," Book I. chap. i.) that many believe the work of Peter Peregrinus on the magnet owes its origin to the opinions of Roger Bacon. And in the Appendix I to Brewer's work—p. 537, chap. vi. "De Experimentis Mirabilibus"—will be found Bacon's views fully exposed on the operations of the magnet.

References.—"Fratris Rogeri Bacon, O. M. Opus Majus," S. Jebb, Londini, 1733; "L'Alchimie et les Alchimistes," Paris, 1860, by Louis Figuier, who, at p. 97, calls Roger Bacon *La plus vaste intelligence que l'Angleterre ait possédée;* "Essai Théorique . . . des connaissances humaines," par G. Tiberghien, Bruxelles, 1844, Vol. I. pp. 388–389; Dr. Geo. Miller, "History Philosophically Illustrated," London, 1849, Vol. II. p. 112; Humboldt, "Cosmos," New York, 1860, Vol. II. pp. 43, 229, 241, 245, 318; "Journal des Savants" for March, April, May and August 1848, also for December 1859 and February 1891; "Origin, Progress and Destiny of the English Language and Literature," by John A. Weisse, New York, 1879, pp. 28, 233–234, 236, 424; "History of Latin Christianity," by Henry Hart Milman, London, 1857, Vol. VI.

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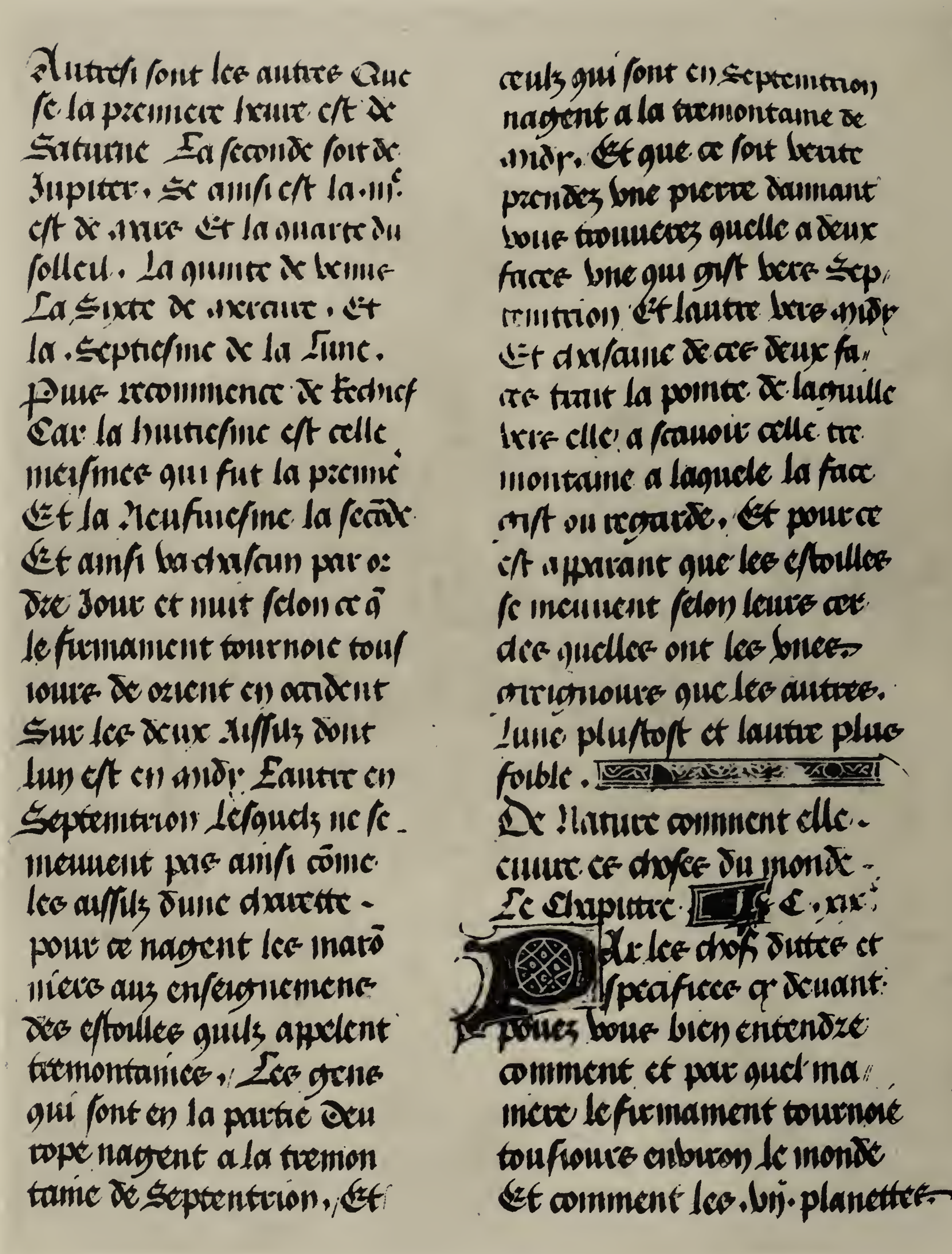
[1] Identified by some authors as John Peckham, a disciple of St. Bonaventura, who became Archbishop of Canterbury from 1278 to 1293 ("Christian Schools and Scholars," by Augusta Th. Drane, London, 1867, Vol. II. p. 172).



Autresi sont les autres Que
se la premiere heure est de
Saturne La seconde soit de
Jupiter. Se ainsi est la .iij.e
est de Mars Et la quarte du
solleil. La quinte de venus
La Sixte de Mercure. Et
la Septiesme de la Lune.
Puis recommence de rechief
Car la huitiesme est celle
meismes qui fut la premiere
Et la Neufiesme la seconde
Et ainsi va chascun par or
dre Jour et nuit selon ce que
le firmament tournoie tous
iours de orient en occident
Sur les deux Aissilz dont
lun est en midy Lautre en
Septentrion Lesquelz ne se
meuvent pas ainsi comme
les aissilz dune charette
pour ce nagent les maro
niers aux enseignemens
des estoilles quilz appelent
tremontaines. Les gens
qui sont en la partie deu
rope nagent a la tremon
taine de Septentrion. Et
ceulz qui sont en Septentrion
nagent a la tremontaine de
midy. Et que ce soit verite
prendez une pierre daimant
vous trouverez quelle a deux
faces une qui gist vers Sep
tentrion et lautre vers midy
Et chascune de ces deux fa
ces trait la pointe de laguille
vers elle a scavoir celle tre
montaine a laquele la face
gist ou regarde. Et pour ce
est apparant que les estoilles
se meuvent selon leurs or
dres quelles ont les unes
greignours que les autres.
Lune plustost et lautre plus
foible.

De Nature comment elle
euvre es choses du monde
Le Chapitre .C.xix.

Par les choses dittes et
specifiees cy devant
pouez vous bien entendre
comment et par quel ma
niere le firmament tournoie
tousiours environ le monde
Et comment les .vij. planettes

Brunetto Latini. "Li livres dou Trésor."
Page taken from the 15th century Ms. in the Bibliothèque Nationale, Paris.

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pp. 279–303; "Opus Majus," by John Henry Bridges, Oxford, 1897, Vol. I. pp. xxv–xxvi, and Vol. II. pp. 203–206, containing a valuable tabulated list of facts relating to Bacon's life; "Roger Bacon," par Emile Charles, Paris, 1861, pp. 15–19, 339–391; "De Bibliorum Textibus," by Dr. Hody; Wm. Whewell, "History of the Inductive Sciences," 1858, Vol. I. pp. 512–522, or 1859, Vol. I. pp. 209–210, 245–246, 512–522, Vol. II. p. 55; also "Philosophy of the Inductive Sciences," London, 1840, Vol. II. pp. 323–337; "The Philosophical Magazine," Vol. XII. pp. 327–337; Enfield, Book VII. chap. iii.; "Catalogue Général des livres imprimés de la Bibliothèque Nationale," Paris, 1901, Vol. VI. pp. 256–259; "Encyclopædia Britannica," Edinburgh, 1842, seventh edition, Vol. I. as per Index at p. 17; "Les Editions de Roger Bacon" in the "Journal des Savants" for July 1905.

A.D. 1260.—Brunetto Latini, *b.* 1230, *d.* 1294, "maestro del divino poeta Dante," celebrated Florentine encyclopædist, composes his "Tesoro," rewritten in French ("Livres dou Trésor"), wherein he speaks clearly of the compass as at some time likely to be useful at sea. But he adds: "No master mariner dares to use it, lest he should fall under the supposition of being a magician; nor would even the sailors venture themselves out to sea under his command if he took with him an instrument which carries so great an appearance of being constructed under the influence of some infernal spirit."

The "Tesoro" is said to be a kind of abridgment of the Bible, of Pliny, of Solinus, of the Ethics of Aristotle, of the rhetorical writings of Cicero and of the political works of Aristotle, Plato and Xenophon ("New Biog. Dict.," London, 1850, Vol. IX. p. 205). It would be well to consult "La Table Générale des bulletins . . . Sociétés Savantes," par M. Octave Teissier, Paris, 1873, p. 44, regarding the collection of different manuscripts of Brunetto's extensive work.

References.—Davis, "The Chinese," 1844, Vol. III. p. xi; Venanson, "Boussole," pp. 75, 148–154; Azuni, "Boussole," p. 139; Klaproth, "Boussole," pp. 45–46; "Journal des Savants" for January 1865, also for January and February 1880; "The Monthly Magazine" for June 1802; Libri, "Hist. des Sciences Mathématiques," Paris, 1838, Vol. II. pp. 64, 152–156.

A.D. 1265–1321.—Dante—Durante—(Alighieri), illustrious Italian poet, regarded as the greatest poetical genius that flourished between the Augustan and Elizabethan ages, composed, during his exile, the "Divina Commedia," which was the first poem written in the Italian language. In Canto XII. vv. 28–30 of his "Paradiso," translated by Dr. Plumptre, he thus alludes to the mariner's compass:

> "Then from the heart of one of those new lights,
> There came a voice which made me turn to see,
> E'en as the star the needle's course incites."

Guido Guinicelli (1240–1276), priest and scholar, and whom Dante considered not only the greatest of living Bolognese poets,

but his master in poetry (Note : "Purg.," XXVI. Vol. I. p. 327, v. 92) refers to the nautical compass in nearly the same terms as Dante ("Rime. Ant.," p. 295). He adds : "The mountains of loadstone give the virtue to the air of attracting iron, but, because it (the loadstone) is far off, (it) wishes to have the help of a similar stone to make it (the virtue) work, and to direct the needle toward the star" (P. L. Ginguené, "Hist. Lit. d' Italie," Vol. I. p. 413; Guido delle Colonne—Io Colonna da Messina—Mandella Lett. p. 81, Florence, 1856).

At pp. 35 and 130 of Bertelli's "Pietro Peregrino di Maricourt," Roma, 1868, Memoria prima, appear verses said to be by Guinicelli and by Guido delle Colonne, judge of Messina, who flourished about 1250, and which are translated literally into English as follows :

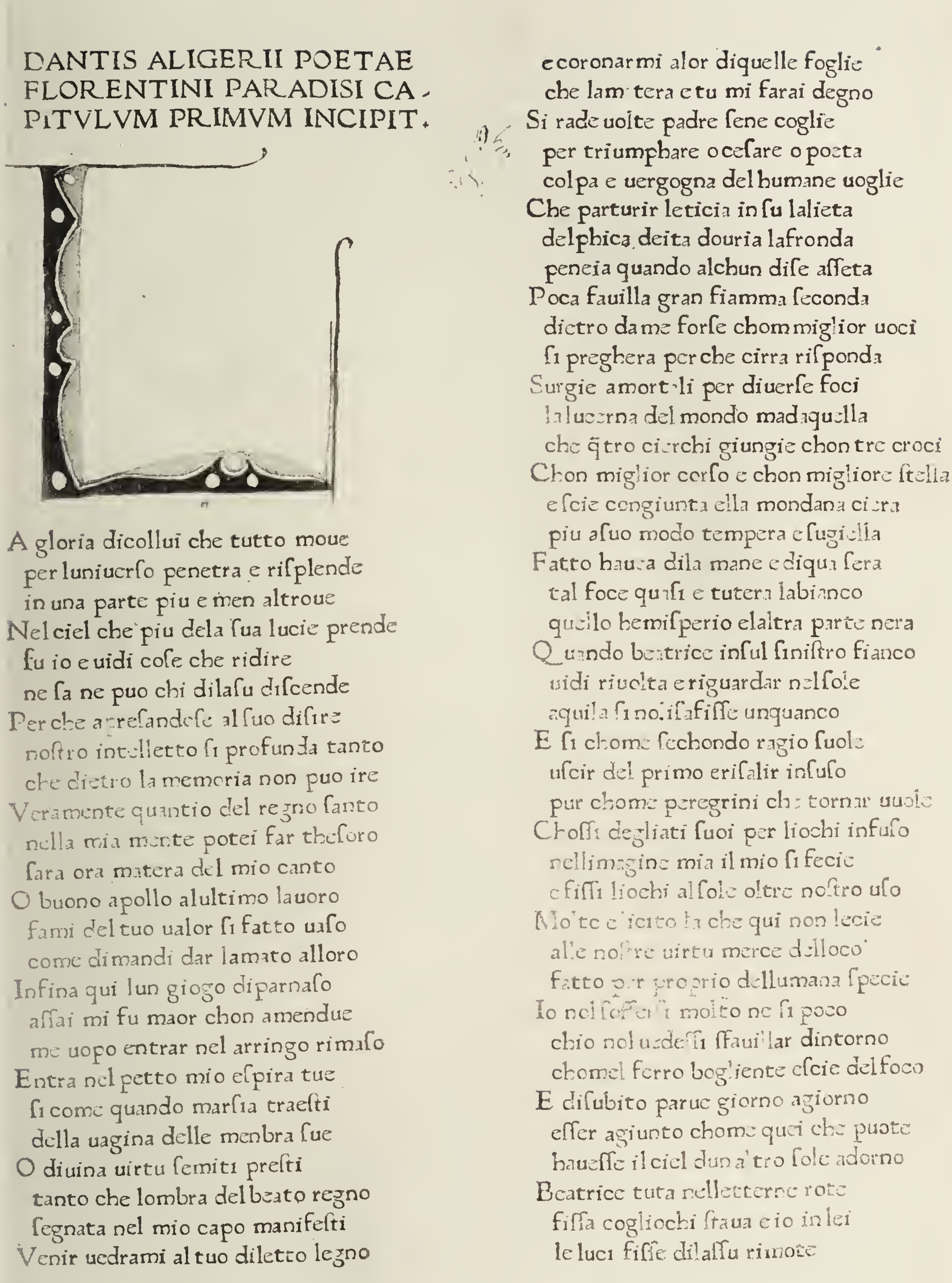
"In those parts under foreign skies
Are the mountains of loadstone,
Which give power to the air
To attract iron, but, because distant,
It requires to have assistance from similar stones,
To bring it into use,
And direct the needle towards the star.

The learned relate that the loadstone
Could not attract
Iron by its power,
Were it not that the air between them aids ;
Although the calamite is a stone,
The other existing stones
Are not so powerful
To attract, because they have not the influence."

The "Paradiso," translated by A. J. Butler, London, 1885, Canto XII. v. 29, reads : "*Si mosse voce, che l'ago* (*needle*) *alla stella,*" and Fazio degli Uberti in the "Dittamondo" (about 1360) has "*Quel gran disio, che mi, traeva addietro come ago a calamita*" (III. 2).

References.—Hœfer, "Nouv. Biog. Gén.," Vol. XIII. pp. 21–50, the last-named page containing an unusual number of citations ; "Biblogr. Dantesca," by Colomb de Batines, Prato, 1845–1846; "La Grande Encyclopédie," Vol. XIII. pp. 887–901, embracing many additional references ; the note at p. 154 of Plumptre's "Dante," also Humboldt's "Cosmos," 1849, Vol. II. p. 629 ; Libri, "Hist. des Sc. Math.," Paris, 1838, Vol. II. pp. 164, etc. ; Frederic C. Harrison, "The New Calendar of Great Men," London, 1892, pp. 310–315.

A.D. 1266.—It is shown by Th. Torffæus (Latin for Thormodr Torfason), an Icelandic scholar (*b.* 1636, *d.* 1719), who published "Historia Rerum Norvegicarum" (Hafniæ, 1711, IV. c. 4, p. 345), that at this date the northern nations were acquainted with the mariner's compass. In the "History of Norway" here alluded to, he mentions the fact that the poem of the Icelandic historian, Jarl Sturla (Snorri Sturlason) written in 1213, on the death of the Swedish


DANTIS ALIGERII POETAE
FLORENTINI PARADISI CA-
PITVLVM PRIMVM INCIPIT.

A gloria dicollui che tutto moue
per luniuerſo penetra e riſplende
in una parte piu e men altroue
Nel ciel che piu dela ſua lucie prende
fu io e uidi coſe che ridire
ne ſa ne puo chi dilaſu diſcende
Per che appreſandeſe al ſuo diſire
noſtro intelletto ſi profunda tanto
che dietro la memoria non puo ire
Veramente quantio del regno ſanto
nella mia mente potei far theſoro
ſara ora matera del mio canto
O buono apollo alultimo lauoro
fami del tuo ualor ſi fatto uaſo
come dimandi dar lamato alloro
Infina qui lun giogo diparnaſo
aſſai mi fu maor chon amendue
me uopo entrar nel arringo rimaſo
Entra nel petto mio eſpira tue
ſi come quando marſia traeſti
della uagina delle menbra ſue
O diuina uirtu ſemiti preſti
tanto che lombra del beato regno
ſegnata nel mio capo manifeſti
Venir uedrami al tuo diletto legno
e coronarmi alor diquelle foglie
che lamtera e tu mi farai degno
Si rade uolte padre ſene coglie
per triumphare o ceſare o poeta
colpa e uergogna del humane uoglie
Che parturir leticia in ſu lalieta
delphica deita douria lafronda
peneia quando alchun diſe aſſeta
Poca fauilla gran fiamma ſeconda
dietro da me forſe chom miglior uoci
ſi preghera per che cirra riſponda
Surgie amortali per diuerſe foci
la lucerna del mondo madaquella
che q̃tro cierchi giungie chon tre croci
Chon miglior corſo e chon migliore ſtella
eſcie congiunta ella mondana ciera
piu aſuo modo tempera e ſugiella
Fatto hauea dila mane e diqua ſera
tal foce quaſi e tutera labianco
quello hemiſperio elaltra parte nera
Quando beatrice inſul ſiniſtro fianco
uidi riuolta e riguardar nelſole
aquila ſi noliſafiſſe unquanco
E ſi chome ſechondo ragio ſuole
uſcir del primo e riſalir inſuſo
pur chome peregrini che tornar uuole
Choſſi degliati ſuoi per liochi infuſo
nellimagine mia il mio ſi fecie
e fiſſi liochi al ſole oltre noſtro uſo
Molte elicito la che qui non lecie
alle noſtre uirtu merce delloco
fatto per proprio dellumana ſpecie
Io nel ſoffer si molto ne ſi poco
chio nol uedeſſi ſfauillar dintorno
chomel ferro bogliente eſcie del foco
E diſubito parue giorno agiorno
eſſer agiunto chome quei che puote
haueſſe il ciel dun altro ſole adorno
Beatrice tuta nelletterne rote
fiſſa cogliochi ſtaua e io in lei
le luci fiſſe dilaſſu rimote

Dante Alighieri. "La Divina Commedia," Mantuae 1472, the first page of what is by many regarded as the oldest edition of the earliest known poem written in the Italian language.
Now in the Bibliothèque Sainte Geneviève, Paris.

Count Byerges, was rewarded with a box containing a mariner's compass.

References.—Suhm, "In effigien Torfæi, una cum Torfænis"; "Nouv. Biogr. Générale de Hœfer," Vol. XLV. p. 495; "New Gen. Biog. Dict.," London, 1850, Vol. XII. p. 263; Jessen, "Norge," pp. 83–99; Larousse, "Dict. Univ.," Vol. XV. p. 312; Michaud, "Biog. Univ.," Vol. XLI. p. 683.

A.D. 1269.—Peregrinus (Petrus), Pierre Pélerin de Maricourt, Méhéricourt—Magister Petrus de Maharnecuria, Picardus—doubtless a Crusader, was, as Roger Bacon tells us ("Opus Tertium," cap. xi) the only one, besides Master John of London, who, at this period, could be deemed a thoroughly accomplished, perfect mathematician, and was one who understood the business of experimenting in natural philosophy, alchemy and medicine better than any one else in Western Europe.

Peregrinus is the author of a letter or epistle, "Written in camp at the Siege of Lucera (delle Puglie—Nucerræ) in the year of our Lord 1269, on the 8th day of August," addressed to his *Amicorum intime*, a soldier, by the name of Sygerus de Fontancourt—Foucaucourt—Foucancort.

Of this epistle, which is the earliest known work of experimental science, there are but few reliable complete manuscript copies. Most of these have been very ably analyzed by P. D. Timoteo Bertelli Barnabita in the exhaustive Memoirs published by him in Rome during 1868, and still better detailed by Dr. Silvanus P. Thompson in his several valuable printed researches and lectures on the subject, but there has been of it only one printed issue in book form, that of the Lindau physician, A. P. Gasser, which appeared at Augsburg during 1558.

Several attempts at translation have been made, notably by Guillaume Libri ("Histoire des Sciences Mathématiques . . ." Paris, 1838, Vol. II. p. 487) who admitted that, with the aid of several paleographers, he could not decipher many of the abbreviated faint characters existing in the Bibliothèque Nationale manuscript (No. 7378A in quarto, at folio 67), and by Tiberius Cavallo, who does scarcely better with the Leyden copy (Fol. Cod. No. 227) which was discovered by him, and but a portion of which he transcribes in the supplement to his "Treatise on Magnetism," London, 1800, pp. 299–320. A translation was also made by Brother Arnold, of the La Salle Institute in Troy, N.Y., and published during 1904, but the most meritorious version now existing is the one entitled "Done into English by Silvanus P. Thompson from the printed Latin versions of Gasser 1558, Bertelli 1868, and Hellmann 1898, and amended by reference to the manuscript copy in his possession,

formerly amongst the Phillipps' manuscripts, dated 1391." This translation, "printed in the year 1902, in the Caxton type, to the number of 250 copies," reflects very great credit upon Prof. Thompson, who has given us such a faithful interpretation of the original work as would naturally be expected at his hands, and who has, besides, rubricated this right royal little volume and caused it to be issued in one of the most attractive typographical fashions of the Chiswick Press.

The Hellmann 1898 Berlin version just alluded to, which appeared in "Neudrucke von Schriften und Karten . . ." No. 10 (*Rara Magnetica*), contains a photographic reproduction of the Augsburg 1558 title-page, and, it may be added, the volume of Phillipps' manuscripts, of which Prof. Thompson became the fortunate possessor, includes one of Chaucer's treatises on the Astrolabe, besides the Peregrinus' manuscript in question.

During the year 1562 much of the original epistle was pilfered by Joannes Taisnier Hannonius, who badly condensed and deformed it and incorporated it as new matter, conjointly with some papers of his own, in a book entitled "Oposculum . . . de Natura Magnetis et ejus effectibus . . ." Coloniæ, 1562; and that much was translated "into Englishe" by Richarde Eden, London, about 1579, under title of "A very necessarie and profitable booke concerning navigation."

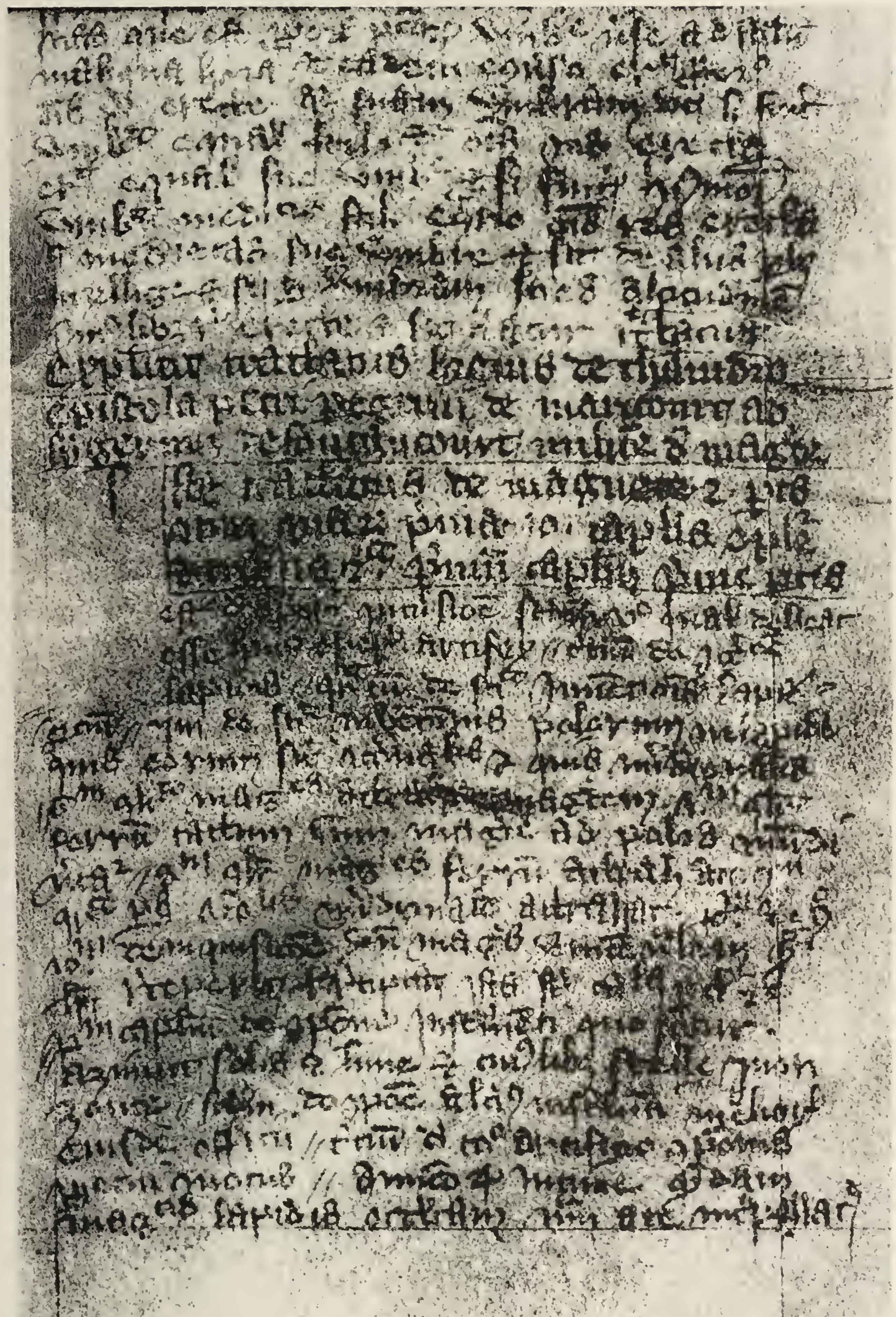
Much has been said at different times regarding the contents of the above-named epistle, the full title of the Paris MS. No. 7378 of which reads

"*Epistola Petri Peregrini de Maricourt ad Sygerum de Foucaucourt militem de magnete,*"

but no *résumé* of it could better be given than by quoting here its first page, which has been translated as follows:

This treatise on the magnet contains two parts, of which Part I is complete in ten chapters, and Part II in three.

Of Part I: Chap. I states the object of the work;
Chap. II, of what the investigator in this line of work should be;
Chap. III, of a knowledge of the load stone;
Chap. IV, of the science of the discovery of the parts of the loadstone;
Chap. V, of the source of the discovery of poles in the loadstone—which of them is the north and which the south;
Chap. VI, in what manner a magnet attracts a magnet;



Petrus Peregrinus. "Epistola . . de Magnete."
The earliest known treatise of experimental science,
now in the Bibliothèque Nationale, Paris.

Chap. VII, how iron touched with the magnet turns towards the poles of the globe;
Chap. VIII, in what manner a magnet attracts iron;
Chap. IX, why the northern part attracts the southern part, and the converse;
Chap. X, of the inquiry whence the magnet derives the natural power it possesses.

Of Part II: Chap. I, on the construction of an instrument (floating compass) by which the azimuth of the sun and moon, and of any star above the horizon, can be ascertained;
Chap. II, on the construction of a better instrument (pivoted compass) for like purpose;
Chap. III, on the construction of a wheel for perpetual motion.

An analyzation of each chapter in turn will show how satisfactorily Peregrinus has developed, in connected series, all of the early experiments upon which are based his theories of the loadstone.

Part I

Chap. I states that the intention or object of the work is to make known the hitherto hidden nature, occult properties, of the loadstone, the art of treating the latter, the making of scientific instruments, and matters of interest to students of nature, astrologers and sailors.

Chap. II. The investigator in this line should know the natures of things and understand the motions of the heavenly bodies, but, above all, he should be assiduous in handiwork for experimental research.

Chap. III indicates four different requisite qualities of the loadstone, and tells where they are to be found and how to select and test them—the best of them being free from flaws, of great density and of a bluish or celestial colour.

Chap. IV shows how to find in the loadstone the two poles, one north and the other south, using preferably a globular magnet,[1]

[1] To Peregrinus is due the first inception of the *terrella*. He makes the magnet round, and says, "You must know that this stone bears in itself a likeness of the heavens and contains two points, one North and the other South, thus resembling the poles of the sky. . . ." In his Memoria Prima, "Sopra P. P. de Maricourt," 1868, P. D. Timoteo Bertelli Barnabita states (Chap. VI. p. 22) that, besides the *terrella*, Gilbert appropriated other observations and experiments of Peregrinus, and, farther on (Chap. VII. p. 28), he gives us the following extract from Thévenot: "*L'on voit encore que la pluspart des choses que l'on attribue à Gilbert et qui luy ont donné la réputation de Père de la Philosophie de l'Ayman estaient scües dès le treizième siècle.*" This,

placing thereon a needle or an oblong piece of iron, and, either drawing lines in the direction taken by the needle, so that they "may meet at two points, just as all the meridian circles of the world meet at the two opposite poles of the world," or, by merely marking the magnet so that "the opposite points will be correctly placed just as are the poles in a sphere."

Chap. V. In order to find the poles in a stone—which of them is the North and which the South—take a round wooden vessel shaped like a skiff (*paropsidis, parascidis*), and place the stone therein, then put the vessel containing the stone into another large vessel filled with water, so that the first-named vessel may float into the larger one: "The stone in the first vessel will be like a sailor in a ship, and the first vessel may float roomily into the second as does a ship in a river, and the stone so placed will turn its small vessel acting as the Northern pole in the direction of the Northern heaven. . . . If this pole were then turned away a thousand times, a thousand times would it return to its place by the will of God."

Chap. VI. Having found which pole is the Northern, mark it so that it may be known when necessary. Place the stone into a small vessel, as shown in Chap. V, then hold another stone in the hand and approach its Northern part to the Southern part of the stone floating in the vessel, and the floating stone will follow the other "as if it wished to adhere thereto. . . . Know that, as a rule, the Northern part of one stone attracts the Southern part of another stone and the Southern the Northern."

Chap. VII. When the needle or oblong piece of iron (alluded to in Chap. IV) has touched the magnet and been attached to a light piece of wood or stalk and then placed in a vessel of

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says he (in a note, pp. 28–29), is doubtless an exaggeration. That Gilbert took from P. Peregrinus his *terrella* and many excellent scientific plans on magnetism, the ideas of others also, is probable, but it is indubitable that much was his own, and that, for his time, his work is a *veritable chef-d'œuvre* of inductive and experimental method and the most finished treatise on magnetism which had up to that time appeared.

In this connection, Bertelli adds (Part III. p. 92): "We must conclude that historical truth was undoubtedly distorted when, for so long a period, it was asserted and repeated, without any sufficient mature investigation, that the famous William Gilbert of Colchester was the real and sole founder of magnetism and of the inductive method in experimental science. We certainly must not deny him the no small merit which is his due, nor the share he had in the discoveries at the commencement of the seventeenth century, but we must, likewise, confess that the copious collection of facts which he gives us, and the experimental and discursive method with which he presents them is neither altogether his own nor is it new" (see W. Wenkebach, "Sur Petrus Adsigerius." Rome, 1865, p. 8; "Universal Lexicon," Leipzig, 1741; N. Cabæus, "Phil. Magn.," Ferrara, 1629, p. 23).

water, one part will be turned towards the mariner's star because it is near the pole, " the fact being that it does not turn towards the aforesaid star but towards the pole." That end of the iron which has touched the Southern end of the stone turns towards the Northern quarter of the sky, and *vice versa*.

Chap. VIII. If you wish to attract iron floating on water, hold the Southern part of a loadstone to the Northern part of the iron and the iron will follow. But, if you bring the North end of the stone near the North end of the iron, the latter will avoid the stone. " If, however, violence is used towards the ends, so that, for instance, the Southern end of the iron which was touched with the Northern end of the magnet is now touched with the Southern end of the magnet . . . the power in the iron will easily be changed, and that will become Southern which was previously Northern, and the converse."

Chap. IX. " The Northern part of the magnet attracts the Southern and the reverse, as has been shown; in which attraction the magnet is an 'agent' of greater power while the 'patient' (*i. e.* the other which is acted upon) is of weaker." This is proved by taking a loadstone—marking it, for instance, AD—dividing, separating it into two parts, and placing one part (the Northern, marked A, called the " agent ") into water so that it will float. It will turn " to the North, as before, for the division does not deprive the parts of the stone of their properties, if it be homogeneous." The other part (the Southern, marked D, called the " patient ") is next to be floated in a similar manner. When this is done, the other ends of the two stones should be marked respectively B and C. It will then be observed that " if the same parts are again brought near each other, one will attract the other, so that they will be joined together again at B and C where the division took place. Whence it is that they become one body with the same natural propensity as at first. The proof of this is that if they are joined together they will possess the same oppositions (opposite poles) they first contained. The 'agent,' therefore, as you will see by experiment, intends to unite its 'patient' to itself, and this takes place on account of the similitude between them. . . . And, in the same way, it will happen that if A is joined with D, the two lines will become one, by virtue of that very attraction, in this order CD — AB . . . there will then remain the identity of the extreme parts as at first, before they were reunited, for C will be the North point and B the South point, as B and C were before. . . . It is therefore

evident, from these observations, why the Southern parts do attract the Northern, and the reverse, and why the attraction of the South by the South, and the North by the North, is not according to Nature."

Chap. X. "Some weak inquirers have imagined that the power which the magnet exercises over iron lies in those mineral places in which the magnet is found . . . but it is found in different parts of the world. . . . Besides, when iron or the magnet turns towards the Southern as well as to the Northern quarter, as is evident from what has already been said, we are compelled to decide that the attraction is exercised on the poles of the magnet not only from the locality of its quarry, from which ensues the evident result that, wheresoever a man may be, the direction of this stone appears to his eye, according to the position of his meridian circle. All the meridian circles, however, meet together at the poles of the globe, wherefore it is that the poles of the magnet receive their power from the poles of the world. From this, it manifestly appears that the direction of the magnet is not towards the mariner's star, as the meridian circles do not meet there, but all the poles, for the mariner's star is always found beyond the meridian circle of any region unless it be twice in a complete revolution of the firmament. Likewise from this, it is manifest that the parts of the magnet receive their power from the world's poles . . . the whole magnet from the whole heavens."[1] Then follows a suggestive experiment looking towards perpetual motion, by which one may secure "a wonderful secret" and even "be saved the trouble of having any clock." Here, it is given that a *terrella*, poised on its poles in the meridian, moves circularly with a complete revolution in twenty-four hours. This is explained by N. Cabæus in his "Phil. Magn.," lib. iii. cap. 4.

Part II

Chap. I. He takes a round, or an ovoid magnet, and, after noting its poles, files it between the two poles on both sides so that it may be like a compressed sphere and thus occupy less space. He then encloses this magnet between two light wooden capsules, or boxes (*cassulas*) after the manner of a mirror . . . so

[1] In this same sense does Ristoro d' Arezzo write in his "La Compositione del Mondo . . . del 1282," transcribed by Enrico Narducci, Roma, 1859, pp. 172, 316, xi, xii. Ristoro calls the needle *angola* (lib. xxxix. p. 326,), which, says he, guides the mariner and which is itself directed (*per la virtu del cielo*) by the star called tramontane (pp. 110, 263–4, 326); see "Pietro Peregrino," Bertelli, 1858, pp. 55, 130.

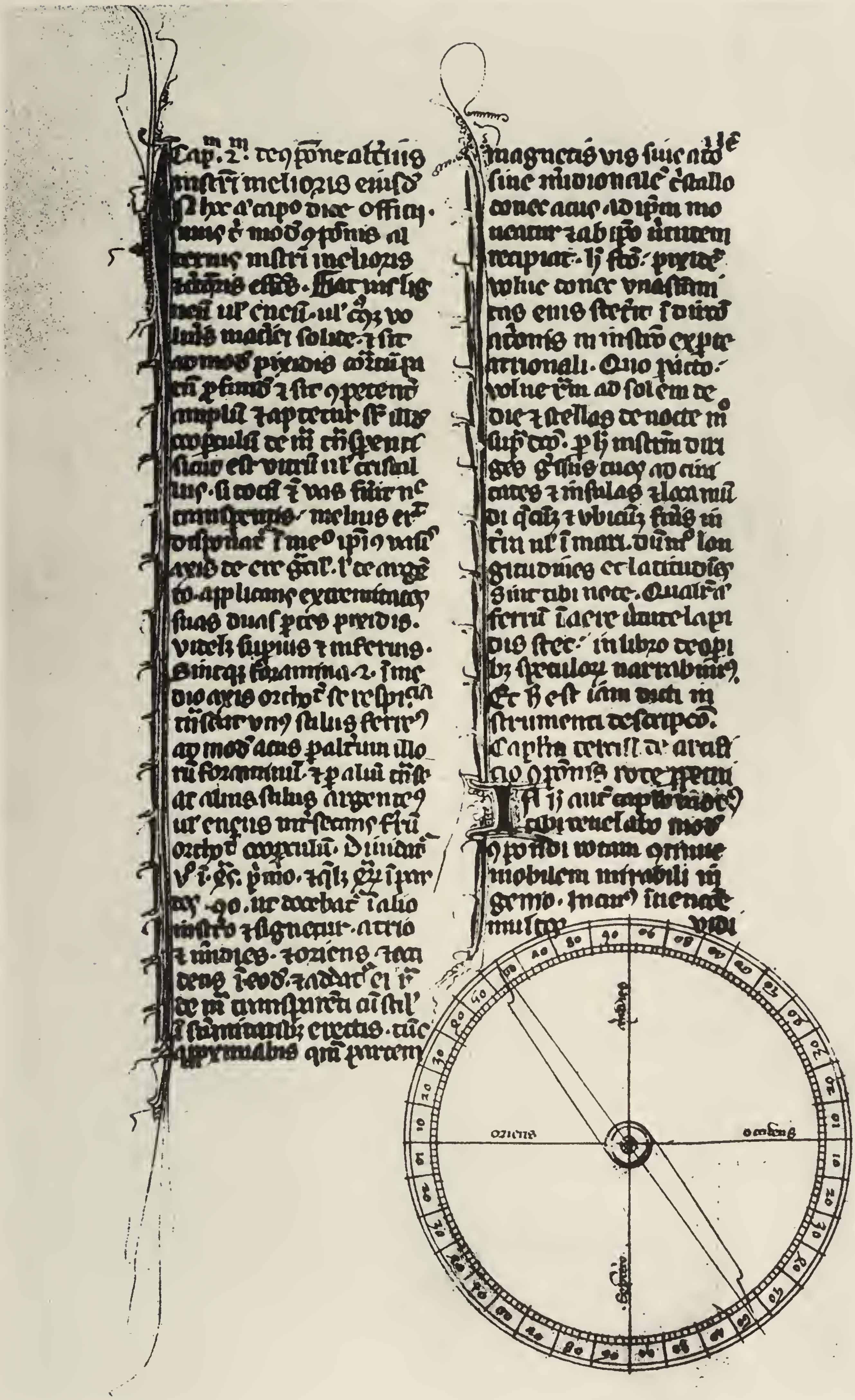
fastened (with glue) that they cannot be opened and water cannot enter. Then, says he, "place the capsules thus adjusted in a large vessel full of water in which the two quarters of the globe, viz. the South and the North, are found and marked, and let them be indicated by a thread extending from the Northern to the Southern part of the vessel; allow the capsules, or boxes, to float and let there be above them a slender piece of wood in the form (position) of a diameter. Then move this piece of wood above the boxes until it is equidistant from the meridianal line previously found and indicated by the thread, or is the same (line) itself. This being done, according to the piece of wood so situated, draw a line on the capsules, or boxes, and it will be the perpetual meridianal line in all countries. That line, therefore, when cut at right angles by another will be divided in the centre and will be the line of the East and West. You will thus have four quadrants actually marked on the capsules, or boxes, representing the four quarters of the globe, of which each will be divided into ninety, so that there may be in the universe CCCLX parts (degrees) in the entire circumference of the capsules, or boxes. Inscribe divisions on it as they were formerly inscribed on the back of the astrolabe. There should be, besides, a slender and light ruler above the capsules so inscribed after the manner of the ruler on the back of the astrolabe. Instead, however, of the sights (*pinnularum*), should be erected at right angles two pins over the ends of the ruler."

This floating compass and the pivoted compass described in the following chapter are to be found illustrated, pp. 67–77, figs. 10 and 12, at end of Part II of Bertelli Barnabita's Memoirs above referred to.

Chap. II. For the construction of a "better instrument and of more certain effects" (the pivoted compass) he says: "Let there be made a vessel of wood, brass or any other solid material that you desire, and let it be turned in the shape of a jar (*pixidis tornatum*) somewhat deep and tolerably large and let a cover of transparent material, such as glass or crystal, be fitted to it. If the whole vessel were of transparent substance so much the better. Let there be placed in the centre of the same vessel a slender axis of brass or silver, applying its extremities to the two parts of the jar, that is to say (to the) higher and lower. Let two holes be then made in the centre of the axis facing each other at right angles. Then let a piece of iron wire, like a needle, be passed through one of these holes and another wire of silver or brass be passed through the other, intersecting

the iron at right angles. Let the cover at first be divided into quadrants and each of the quadrants into ninety parts, as was taught regarding the other instrument. Let North and South and East and West be marked on it and let a rule of transparent material be added to it with wires set upright at the ends. You will approach what part of the magnet you please, whether North or South, to the crystal until the needle moves towards it and receives virtue from it. When this is done, turn the vessel until one end (of the needle) stands directly over the North in the instrument coinciding with the Northern quarter of the sky. This being done, turn the rule to the sun, by day, and to the stars, by night, in manner above indicated. By means of this instrument, you will be enabled to direct your footsteps to states and islands and to any places on the globe, and wheresoever you may be, whether on land or on sea, so long as their latitudes and longitudes are known to you."

Chap. III. He constructs "a wheel which shall be constantly in motion," by making a very thin concave, silver case, after the manner of a mirror, suitably perforated, around the rim of which he inserts small iron nails, or teeth, bent closely toward each other and which he then places upon an immovable axis so that it may revolve easily." He continues : "Let a silver wire be added to this axis, fixed to it and placed between two bowls on the end of which let a magnet be set, prepared in this manner. Let it be rounded and its poles ascertained, as before indicated; afterwards, let it be fashioned in the shape of an egg with the poles intact, and let it be somewhat filed down in two intermediate and opposite parts with the object of its being compressed and occupying less space so that it may not touch the inner walls . . . let the magnet be placed on the wire . . . and let the North pole be somewhat inclined towards the small teeth of the wheel so that it may exercise its power . . . so that each tooth shall arrive at the North pole and, owing to the impetus of the wheel, shall pass it by and approach the Southern quarter. Thus every small tooth will be in a perpetual state of attraction and avoidance. And, in order that the wheel may perform its duty with greater rapidity, insert, between the cases, a small round brass or silver pebble of such size that it may be caught between any two of the small teeth, so that, as one part of the wheel comes uppermost, the pebble may fall to the opposite part. Wherefore, whilst the motion of the wheel is perpetual on one side, the same will be in the case of the pebble on the other side, or the fall of the pebble caught between any two of the teeth will be perpetual to the



Petrus Peregrinus. Facsimile of a Ms. at the Bodleian Library, of the "Epistola de Magnete," wherein is described the earliest known pivoted compass.

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opposite side because as it is drawn towards the centre of the earth by its weight, it assists the motion by not suffering the small teeth to remain at rest in front of the stone. Let there be spaces, however, between the small teeth conveniently curved, so as to catch the pebble as it falls in the way the present description indicates."

Gilbert alludes to this perpetual-motion engine as having been devised or delineated by Peregrinus after he had got the idea from others ("De Magnete," Book II. chap. xxxv.), and says that Jerome Cardan writes ("Opera," Batav., 1663; "De Rerum Varietate," Book, IX. chap. xlviii.) he could construct one out of iron and loadstone—not that he ever saw such a machine; that he merely offers the idea as an opinion and quotes from a report of the physician Antonio de Fantis of Treviso published in "Tabula generalis ac mare magnum scotice subtilitatis. . . ."

In the "Magisterium Naturæ et Artis," P. Francisci Tertii de Lanis, Brixiæ, 1684, Tractatus Tertius, Caput Secundum, p. 489, under Problema, I, *Motus perpetuus magnetis*, will be found allusion to the machines of (1) P. Peregrinus, as described in his epistle; (2) Taisnier; (3) Ant. de Fantis (cited by Cardan, as stated above); also mention of those of P. Schottus, Athan. Kircherus, Hieronimus Finugius and others; the most important of these being again alluded to throughout the third chapter of the same tract.

Gilbert makes further allusion to P. Peregrinus in his Book I. chap. i.; Book II. chap. xxxv.; Book III. chap. i.; Book IV. chap. i.; Book VI. chap. iv.

The Peregrinus' Leyden manuscript (Fol. Cod. No. 227) already alluded to, Libri says ("Histoire des Sciences Mathém. . . ." 1838, Vol. I. p. 383, note), is but a poor copy of the manuscript in the Paris Library (No. 7378A), from which latter the words *Petri ad Sygerum* have been unfortunately transformed into *Petri Adsigerii*. He adds (Vol. II. pp. 70–71) that Humboldt cites ("Examen Critique," p. 243) several authors who have alluded to the pretended Adsigerius. Mention is also made of the fact that W. Wenkebach, professor at the Hague Military School, examined the manuscripts in the Bodleian Library, Nos. 1629, 1794 and 2458, containing the treatise of Peregrinus, and that not one of them has the passage alluding to the declination. The Leyden manuscript, by the way, is said to be the only one, besides the Vatican copy, No. 5733, bearing the full date, which latter was first made known by Thévenot in his "Recueil de Voyages." And it was a passage found in the Leyden manuscript (Q 27) which led to the belief that Peregrinus had first observed the variation or declination of the magnetic needle. The

passage is as follows: "Take note that the magnet, as well as the needle that has been touched by it, does not point exactly to the poles, but that the part of it which is supposed to point to the South sometimes declines a little to the West, and that the part which looks towards the North sometimes inclines to the East. The exact quantity of this declination I have ascertained, after numerous experiments, to be five degrees. However, this declination is no obstacle to our guidance, because we make the needle itself decline from the true South by nearly one point and a half towards the West. A point contains five degrees." This passage is unquestionably a late addition, being written in a different hand in a circle which itself is an incompleted outline of one of the figures of Peregrinus' primitive compass.

References.—"Encyclopædia Metropolitana," Vol. III. p. 737 ("Bibliotheca Bibliothecarum," fol. 11, p. 1400; "Catalogue of the MSS. in the library of Geneva," by Senebier, p. 207); "Bulletino di bibliographia e di storia delle scienze . . ." B. Boncompagni, Vol. I. pp. 1–32, 65–99, 101–139, 319–420; Vol. IV. pp. 257–288, 303–331; "Cat. bibl. publicæ univers. Lug. Bat.," p. 365; W. Wenkebach, "Sur Petrus Adsigerius . . ." Rome, 1865 (taken from Vol. VII. No. 3 of the "Annali Pura ed Applicata"); Brunet, "Manuel du Libraire," 1863, Vol. IV. p. 493; "Br. Museum Library," 538, G 17; "Journal des Savants," for April–May 1848, and September 1870; Walker, "Magnetism," 1866, p. 6; "English Cyclopædia," Vol. VIII. p. 160, also Dr. Hutton's "Phil. and Math. Dictionary"; Thos. Young, "A Course of Lectures on Nat. Phil. and the Mechanical Arts," London, 1807, Vol. I. pp. 746, 756; "Electro-magnetic Phenomena," by T. A. Lyons, New York, 1901, Vol. I. pp. 105–106; Vol. II. p. 565 (with translation of a portion of the original manuscript); "Examen Critique," A. de Humboldt, Paris, 1836, Vol. III. p. 31; "Science and Literature of the Middle Ages," Paul Lacroix, London, pp. 88–89, 280–282; Silvanus P. Thompson, "Proceedings of the British Academy," 1905–6, p. 377. It may be added that Houzeau et Lancaster, "Bibl. Générale," Vol. I. part i. p. 640, allude, at No. 3197, to a manuscript of P. Peregrinus, "Nova compositio astrolabii particularis," as being in the Library of Geneva and as citing the year 1261 in connection with the astronomical tables of John Campan (Campanus, Italian mathematician, who died about 1300): "Biog. Générale," Vol. VIII. p. 373.

A.D. 1270.—Riccioli (Giovanni Battista), an Italian astronomer, member of the Society of Jesuits, *b.* 1598, *d.* 1671, asserts that at this period under the reign of St. Louis (1226–1270), French navigators were already using the magnetic needle, which they kept floating in a small vase of water, and which was supported by two tubes to prevent its falling to the bottom.

For a detailed account of the work of this well-known scientist consult: "Biographie Générale," Vol. XLII. pp. 147–149; Fabroni, "Vitæ Italorum," Vol. II; Jean Baptiste Delambre, "Hist. de l'Astron. Mod.," 1821; Davis, "The Chinese," Vol. III. p. 11; Venanson, "Boussole," pp. 70–71; Klaproth, "Boussole," p. 54; Becquerel, "Résumé," p. 59; Alex. Chalmers, "Gen. Biog. Dict.,"

1811, Vol. XXVI. pp. 182–183; Fischer, "Geschichte der Physik," Vol. I; Tiraboschi, "Storia della letter. Ital.," Vol. VIII; "English Cyclopædia," Vol. V. pp. 76–77. Riccioli's "Almagestum Novum," Bologna, 1651, in two volumes, gives in book nine of the second volume the sentence of Galileo. This is the work which an old savant called "the pandects of astronomical knowledge" (Morhof Polyhistor, Vol. II. p. 347).

A.D. 1271–1295.—Polo (Marco), Paulum Venetum, is reported by many to have brought the compass from China to Italy. This is, however, supported by no evidence, nor is any allusion whatever made to the fact in the account he rendered of his voyage. Before Marco Polo set out on his travels, as Humboldt states, the Catalans had already made voyages "along the northern islands of Scotland as well as along the western shores of tropical Africa, while the Basques had ventured forth in search of the whale, and the Northmen had made their way to the Azores (the Bracir islands of Picignano)."

Polo relates that he set out from Acre in 1271, and returned to Venice "in the year 1295 of Christ's Incarnation." His "Travels" ("Il Milione di Messer Marco Polo") according to the review of Col. Henry Yule, consists of a prologue and four books. It was dictated by him to a fellow prisoner, Rusticiano or Rusticello, of Pisa, and "it would appear now to be definitely settled that the original was . . . of just such French as we might expect in the thirteenth century from a Tuscan amanuensis following the oral dictation of an Orientalized Venetian."

Polo's journeyings extended "so far to the north that he leaves the North Star behind him, and thence so far to the south that the North Star is never seen."

References.—Becquerel, "Elec. et Magn.," Vol. I. p. 70; Sonnini, in Buffon, "Minéraux," Vol. VI. p. 84; Humboldt, "Cosmos," 1849, Vol. II. pp. 625, 656, or 1860, pp. 250–251; "The Book of Ser Marco Polo," by Sir Henry Yule, New York, 1903, which contains a very extensive bibliography at end of the second volume; Libri, "Hist. des Sc. Mathém.," Paris, 1838, Vol. II. pp. 26, 140, etc.; D. A. Azuni, "Dissertation sur la Boussole," p. 69; Miller, "Hist. Phil. Ill.," 1849, Vol. I. pp. 179–180; "Encycl. Brit.," ninth ed., Vol. XIX. p. 407; "Journal des Savants" for September 1818, also May 1823, and the five articles published January to May 1867; see also "Centennaire de Marco Polo," par. H. Cordier, Paris, 1896, containing "bibliographie très complète de toutes les éditions de Marco Polo et des ouvrages qui lui sont consacrés."

A.D. 1282.—Baïlak, native of Kibdjak, wrote this year, in Arabic, his book on "Stones," wherein he says that he saw during his voyage from Tripoli to Alexandria, in 1242, the captains of the Syrian sea construct a compass in the following manner: "When

the night is so dark as to conceal from view the stars which might direct their course according to the position of the four cardinal points, they take a basin full of water, which they shelter from wind by placing it in the interior of the vessel; they then drive a needle into a wooden peg or a corn-stalk, so as to form the shape of a cross, and throw it into the basin of water prepared for the purpose, on the surface of which it floats. They afterwards take a loadstone of sufficient size to fill the palm of the hand, or even smaller; bring it to the surface of the water, give to their hands a rotatory motion towards the right so that the needle turns on the water's surface; they then suddenly and quickly withdraw their hands, when the two points of the needle face north and south. I have seen them, with my own eyes, do that during my voyage at sea from Tripolis to Alexandria."

REFERENCES.—E. Salverte, "Phil. of Magic," New York, 1847, Vol. II. pp. 221–222, note; "American Journal of Science and Arts," Vol. XL. p. 247; Davis, "The Chinese," Vol. III. p. xii; Klaproth, "Lettre à M. de Humboldt," pp. 59, 60, 67; Knight, "Mech. Dict.," Vol. II. pp. 1371 and 1397; "Electro-Magn. Phenom.," by T. A. Lyons, New York, 1901, Vol. II. p. 564.

A.D. 1302.—Gioia—Goia (Flavio or Joannes), an Italian pilot reported born at Positano, near Amalfi, is said by Flamnius Venanson ("De l'invention de la boussole nautique," Naples, 1808, pp. 138 and 168) to be the real inventor of the mariner's compass. This view is supported by Briet (Philippe), "Annales Mundi," Vol. VI: Géog. et Hydrog., lib. x. cap. 8; by Voltaire ("Essai sur les Mœurs," 1819, Vol. III. chap. cxli.), and by many others, but Klaproth ("Lettre . . ." 1834, pp. 132–136) quotes Anthony of Bologna, called the Panormitan, as saying that Gioia lived in the fourteenth century and wrote both "*Prima dedit nautis usum magnetis Amalphis*" and "*Inventrix præclara fuit magnetis Amalphis.*" He adds that a statement to the same effect was made by Arrigi Brechmann in his "Historia Pandectarum Amalphitorum," Dissertatio I, No. 22, Neapoli, 1735, p. 925, but that both are equally incorrect, for Gioja could not have invented an instrument which had already been in use more than a hundred years before his time.[1]

[1] Dr. Geo. Miller names ("Hist. Phil. Ill.," London, 1849, Vol. I. p. 180, note) Guyot de Provins, Jacques de Vitry and Brunetto Latini, as referring to the compass. He adds that the Chronicle of France intimates the use of this instrument under the name of *marinette* towards the time of the first of the voyages of the Crusaders undertaken by Louis IX, and that Hughes de Bercy, a contemporary of that prince, speaks of it as well known in that country. For these reasons, says he, "the credit of the invention must be denied to Flavio de Melfi, or Flavio Gioia, a Neapolitan, who is commonly said to have constructed the first compass about the year 1302, on account of which the province of Principato, in which he was born, bears one of these instruments for its arms."

In his "Essay on Several Important Subjects," London, 1676, Joseph Glanvill remarks (p. 33) : "I think there is more acknowledgment due to the name of this obscure fellow, that hath scarce any left, than to a thousand Alexanders and Cæsars or to ten times the number of Aristotles and Aquinas'. And he really did more for the increase of knowledge and advantage of the world, by this one experiment, than the numerous *subtile disputers* that have lived ever since the creation of the School of Wrangling."

In the "Navigator's Supply," published 1597, William Barlowe speaks of "the lame tale of one Flavius at Amelphus in the Kingdome of Naples; for to have devised it (the compass) is of very slender probabilitie."

M. D. A. Azuni says ("Boussole," 1809, p. 144) that Gioja may have possibly invented the method of suspending the magnetic needle upon a perpendicular pivot so that it would remain horizontal whatever the movements of the vessel. This is very likely; at any rate, it must be admitted that this particular mode of support permits a freer movement to the needle in any direction and admits of more exact observations than when the needle is floating upon the water.

At pp. 487–505, Vol. II of his "Histoire des Sciences Mathématiques," Guillaume Libri transcribes all he is able to from the almost illegible Peter Peregrinus' manuscript, No. 7378A, in the Paris Bibliothèque, and refers to the imperfect mode of suspending the magnetic needle therein shown. It is, says he, similar to that spoken of by Francesco da Buti (Libri, Vol. II. pp. 67–68; Bertelli, "Pietro Peregrino," pp. 63–66), who makes first mention of the compass in the Dante commentary ("Comment, sopra la Divina Commedia") to be found in the collection of manuscripts No. 29, held by the Magliabechiana Library of Florence. He adds that the suspension of the needle is likewise alluded to by Guerino detto il Meschino, in a work first composed prior to the "Divina Commedia" (an Italian romance, attributed to one Andrew the Florentine) as *imbellico*, or *in bellico, in bilico*, meaning in suspense, throughout the editions of Padua, 1473, Bologna, 1475, Milan, 1482 and Venice, 1480, 1498. Mention is also made by Libri of the writings of Adélard de Bath on the compass, at p. 62 of his second volume.

REFERENCES.—Camillus Leonardus, "Speculum Lapidum"; the notes at p. 180, Vol. I. of Dr. Geo. Miller's "Hist. Phil. Ill.," London, 1849, Vol. I. p. 179, note; Venanson, "Boussole," pp. 158, 160; Knight, "Mech. Dict.," Vol. II. p. 1398; Collenutius—Collenuccio—"Compendio . . . regno di Napoli," Venice, 1591; "Discussione della leggenda di Flavio Gioia, inventore della bussola" (T. Bertelli, in "Rivista di Fisica Mat. e Sc. Nat.," Pavia, 1901, II. pp. 529–541); Matteo Camara, "Memorie . . . di Amalfi," Salerno, 1876; "Literary Digest," July 6, 1901, translated from "Le Cosmos," Paris, June 8, 1901; Giraldi,

"Libellus de Re Nautica," Bâle, 1540; Admiral Luigi Fincati, "Il Magnete, la calamita e la bussola," Rome, 1878; "Annales de Géographie," Vol. XI. No. 59, pp. 7–8 for September 15, 1902, and G. Grimaldi in the "Mem. d. Accad. Etrus. di Cortona"; Paulus Jovius, "Historiarum," Florence, 1552; Pietro Napoli Signorelli, "Sull' invenzione della bussola nautica . . ."; M. A. Blondus, "De Ventis," Venice, 1546; Cælius Calcagninus, "Thesaurus Græcarum Antiquitatum," 1697, Vol. XI. p. 761; Houzeau et Lancaster, "Bibl. Gén.," Vol. II. p. 149; "Riv. G. Ital.," X. 1903, pp. 1, 11, 105–122, 314–334.

For Briet (Philippe), *b.* 1601, *d.* 1668, see Michaud, "Biog. Univ.," Paris, 1843, Vol. V. p. 527. The best, most complete edition of Briet's "Annales Mundi" is the Venice, 1693.

A.D. 1327–1377.—It has been claimed by F. M. Arouet de Voltaire, who asserts it at Vol. III. pp. 251–252 of his "Essai sur les Mœurs et l'Esprit des Nations," Paris, 1809, "that the first well-authenticated use of the compass" was made by the English during this period, which is that of the reign of King Edward III.

By Voltaire, the extraordinary (*prodigieuse*) antiquity of the Chinese is not questioned. They knew of the compass, but he says "it was not employed by them for its proper use, that of guiding vessels at sea. They travelled only along the shores. Possessed, as they were, of a country that furnished everything, they did not feel the need of going, as we do, to the other end of the world" (Vol. I. pp. 239, 247). Speaking of the Portuguese (Vol. III. p. 257) he says: "It was not before known if the magnetic needle would point to the south on approaching the South Pole; it was found to point constantly to the north during the year 1486."

From the time of Edward III, the compass was known in England by the names of *adamant, sailing needle* and *sail-stone dial*, as has been shown in the writings of Chaucer and others, the most important of which will be duly quoted in their order. The compass was alluded to, more particularly, by John Gower, "Confessio Amantis,"[1] Books I and VI; by Richard Hakluyt, "Voyages," Vol. I. pp. 213, 215; and by Edward Fairfax, "Godefroy de Boulogne," Book XV. s. 18.

It may be well to record here that Voltaire was "confessedly the foremost name, the acknowledged head of European literature of his time." Goethe calls him "the greatest literary man of all time, the most astonishing creation of the Author of Nature" ("Nouvelle Biographie," Vol. XLV. i. p. 445). Though not the first French author who wrote on the wonderful discoveries of Newton, he was the first to make them extensively known on the Continent.

[1] It is interesting to note that the "Confessio Amantis," which went through as many as four editions before the year 1560, is a huge work of nearly thirty-five thousand lines which was written at the desire of King Richard II of England between the years 1377 and 1393.

References.—Sir Harris Nicolas, "Hist. Roy. Navy," 1847, Vol. II. p. 180; Humboldt, "Cosmos," 1859, Vol. V. p. 57, note; Whewell, "Hist. of the Ind. Sc.," 1859, Vol. I. p. 431; "Crit. and Misc. Essays," by Thomas Carlyle, Boston, 1860, pp. 5–78. "La France Littéraire," par Joseph M. Quérard, Vol. X. Paris, 1839, pp. 276–457, devotes as many as 182 pages to bibliographical notices of Voltaire and names 1131 publications written by or relating to him, whilst in Quérard's "Bibliographie Voltairienne" will be found a still more extended account at pp. i–xxxvi and at pp. 1–84.

The Mariner's Compass

Regarding the mariner's compass, it can scarcely be doubted, from what precedes, that it came to the knowledge of Europeans in the manner indicated under the A.D. 1190 date.

Baïlik of Kibdjak—Baüak Kibdjaki—spoke of its use as generally well known by the Syrian navigators, who constructed it in exactly the same way as did the Chinese (A.D. 1111–1117 and A.D. 1282), and which resembled the compass seen by Brunetto Latini in the possession of Friar Bacon while in England prior to the year 1260 (Knight, "Mech. Dict.," Vol. II. p. 1397).

Edrisi (Idrisi or Aldrisi), the most eminent of the Arabian geographers, is said by Boucher to have given a confirmed account of the polarity of the magnet, the early knowledge of which by the Arabs has been shown conclusively by Jacob de Vitry, Vincent de Beauvais and Albertus Magnus.

Signor P. T. Bertelli, who has been mentioned under the A.D. 1190 date, could not find any reference, however remote, to the directive property of the loadstone throughout a careful examination of Latin and Greek works dating from the sixth century B.C. to the tenth century A.D. He admits that the directive property was known to the Chinese, who had made rude floating needle compasses before the beginning of the Christian era, although these compasses are likely to have been brought home by the Amalfian sailors, who are, by some writers, represented as having substituted the pivoted needle as well as added the Rose of the Winds.[1] He will not, however, recognize the claims made in favour of Flavio Gioja. On the other hand, A. Botto has shown that the Amalfitans introduced the compass between the tenth and the eleventh centuries ("Contributo agli studi storici sull' origine della bussola nautica," 1899). Consult likewise Vol. IX of "Annales de Géogr. et de Bibliogr.," 1899, p. 8.

At p. 195 of the December 1904 issue of "Terrestrial Mag-

[1] Les Roses des Vents n'apparaissent pas sur les cartes avant le xvi^e siècle ("Annales de Géographie," VI. 1897, p. 14 de la Bibliographie). See A.D. 1436 entry.

netism " is a short article relative to the claim made that the compass was invented by a Veronese named Salomone Ireneo Pacifico (A.D. 776–846) during the first half of the ninth century. It states that Bertelli considers this due to a misinterpretation of an inscription on Pacifico's tomb, and it alludes to Bertelli's previous paper on the subject in " Terrestr. Magn.," Vol. VIII. No. 4, p. 179 (see also the number of " Terrestr. Magn." for June 1905, p. 108, and the " Geographical Journal " for March 1905, pp. 334–335).

The earliest recorded use of the compass in a Spanish vessel, according to Capmany (" Memorias Historicas," 1792), is to be found in the Chronicle of Don Pedro Niño, Conde de Buelna, as follows : " It is reported that Conde's galleys left the island of La Alharina along the coast of Bombay . . . and the pilots compared their needles which had been rubbed with the magnet stone. . . ."

In Dr. Plumptre's notes on Dante, reference is made to the fact that the European knowledge of the magnetic needle came from Arabia, and, like Humboldt, he quotes in support thereof an allusion from the Spanish " Leyes de las Partidas " belonging to the first half of the thirteenth century. The passage in the last named is spoken of by M. Fern de Navarrete in his " Discurso historico," etc., 1802 (II. tit. ix. ley 28) and reads thus : " The needle which guides the seaman in the dark night and shows him, both in good and in bad weather, how to direct his course is the mediatrix (*medianera*) between the loadstone (*la piedra*) and the north star . . ." Humboldt adds : " See the passage in ' Las siete Partidas del sabio Rey Don Alonso el IX' [according to the usually adopted chronological order, Alfonso the tenth], Madrid, 1829, Vol. I. p. 473." [1]

On the other hand, the knowledge of the compass by the Arabs in the thirteenth century has been most decidedly contested by E. Renaudot (" Anciennes Relations des Indes et de la Chine," Paris, 1717, p. 3); by D. A. Azuni (" Dissertation sur l'origine de la Boussole," Paris, 1809, pp. 102, 127; by Giovanni Battista Ramusio (" Coll. Voy.," 1554, Vol. I. p. 379); by A. Collina (" Considerazioni," etc., Faenza, 1748, p. 121, etc.). Buffon says (" Théorie de la Terre," Paris, An. VIII. tome i. p. 300) : " I know that some pretend the Arabs have invented the compass and have used it long before the French (see ' Abrégé de l'histoire des Sarrazins,' de Bergeron, p. 119) . . . but that opinion always appeared to me

[1] Incidentally, it may be mentioned that when the laws of Castile were collected in a Code, during the reign of Alfonso the tenth, surnamed *El Sabio*, the learned, the compilers divided the work into seven volumes or parts (*siete partidas*) in order that each volume or part might be dedicated to one of the seven letters constituting Alfonso's name (" Dedication of Books," New York, 1881, pp. 17–18).

devoid of reason; for there is no word in the Arabian, Turkish or Persian tongue which can be made to signify the compass. . . . They employ the Italian word *bossola*. . . ."

The same view is entertained by Dr. William Robertson, principal of the University of Edinburgh, who, after announcing in his "History of the Reign of Charles V," London, 1769, Vol. I. p. 78, that the mariner's compass was invented soon after the close of the Holy War, gives at pp. 333–335 of his "Historical Disquisition," London, 1812, a translation of the above passage taken from an early edition of that illustrious French naturalist George Louis Le Clerc, Comte de Buffon. Robertson adds: "This shows that the knowledge of this useful instrument was communicated to them (the Arabs) by the Europeans. There is not one single observation of ancient date made by the Arabians on the variation of the needle, or any instruction deduced from it for the assistance of navigators. . . . When Mr. Niehbuhr was at Cairo, he found a magnetic needle in the possession of a Mohammedan which served to point out the *Kaaba*, and gave it the name of *el magnetis*, a clear proof of its European origin."

The claims of France to the discovery of the compass have been laid by some to the fact that the north point of the early instruments was generally drawn in the form of a *fleur de lys*, but Voltaire says ("Essai," etc., Vol. III. p. 251), that the Italians drew this in honour of the sovereigns of Naples, a branch of the French royal family. The able writer in the English Cyclopædia ("Arts and Sciences," Vol. III. p. 102) considers the design to be only "an *ornamented cross* which originated in devotion to the mere symbol; though, as the compass undoubtedly came, he says, into Europe from the Arabs, the *fleur de lys* might possibly be a modification of the *mouasala*, or dart, the name by which the Arabs called the needle" ("Phil. Mag.," Vol. XVIII. p. 88).

REFERENCES.—Hallam, "Middle Ages," Vol. III. chap. ix. part ii.; Klaproth, "La Boussole," pp. 53, 54 and 64–66; Davis, "The Chinese," Vol. III. p. 12; "Silliman's Journal," XL. 242–250; "Nautical Magazine," April 1903; "Ciel et Terre," Juin 1, 1904, pp. 156–158; "Histoire de la Boussole," par P. D. M. Boddært; Libri, "Hist. des. Sc. Mathém.," Paris, 1838, Vol. I. pp. 136–137, 382, etc.; Article "Bussola" in "Nuova Encycl. Italiana," by Bocardo, Vol. IV. Torino, 1877, p. 377, poesia di Ugo di Sercy (Bercy) e di Giovanni di Mehun; "Harper's Magazine," New York, for February, 1904; V. Molinier, "Notice . . . boussole au xiii^e siècle," Toulouse, 1850; G. Grimaldi, "Dissert . . . della bussola," Roma, 1741; McCulloch, "Traités . . . boussole," Paris, 1853; Magliozzi, "Notizie . . . bussola," Napoli, 1849; Dr. Geo. Miller, "Hist. Phil. Illust.," London, 1849, Vol. I. p. 180, note. For Edrisi, see "Journ. des Savants," issued in April and August 1843, and in December 1846.

A.D. 1391.—Chaucer (Geoffrey), the father of English poetry,

thus expresses himself in "The Conclusions of the Astrolabie" ("English Poets," London, 1810, Vol. I): "I haue giuen thee a sufficient astrolabye for oure orizont compowned after the latitude of Oxenforde. . . . Now hast thou here, the fower quarters of thin astrolabie, deuided after the fower principall plages or quarters of the firmament. . . . Now is thin Orisonte departed in XXIIII partiez by thi azymutz, in significacion of XXIIII partiez of the world; al be it, so that ship men rikne thilke partiez in XXXII."

"Now maugre Juno, Aneas
For all her sleight and her compas
Atcheiued all his auenture."
"House of Fame," B. I.

"The stone was hard of adamaunt,
Whereof they made the foundemaunt,
The tour was round made in compas,
In all this world no richer was."
"Rom. of the Rose."

"Right as betwene adamants two
Of euen weight, a pece of yron set,
Ne hath no might to moue to ne fro
For what that one may hale, that other let."
"Assem. of Foules."

References.—"English Poets," London, 1810, Vol. I. p. 453; Ch. Wells Moulton, "Library of Literary Criticism," Vol. I. pp. 77–81.

A.D. 1436.—Bianco—Biancho—(Andrea), was an Italian cartographer living at Venice early in the fifteenth century, who published, in 1436, an atlas exhibiting charts of the magnetic variation. The knowledge of the latter, which is so indispensable to the correction of a ship's reckoning, was then ascertained less by the sun's rising and setting than by the polar star.

One of Bianco's charts, now in the Biblioteca Marciana, Venice, shows two islands at the West of the Azores, leading many to believe that he possessed some knowledge of the existence of North and South America.

In Justin Winsor's description of Dr. John G. Kohl's collection of early maps ("Harvard Univ. Bulletin," Vol. III. pp. 175–176), it is said that the original of Andrea Bianco's Map of the World A.D. 1436, now at Venice, was reproduced by Joachim Lelewell ("Géographie du Moyen Age," Pl. XXXII), and also in M. F. de Barros de Santarem's "Essai sur l'histoire de la cosmographie et de la cartographie" (Pls. XXIII, XLIII).[1] Reference is also made thereto in Winsor's "Bibliography of Ptolemy's Geography," sub

[1] See "Geographical Journal," Vol. V. March 1895, No. 3, "Pre-Columbian Discovery of America," pp. 222, 224, 226, for sketches of Andrea Bianco's Map of 1448.

anno 1478. Mr. Winsor adds : " Bianco's views are of interest in early American cartography from the deductions which some have drawn from the configuration of the islands ' Antillia ' and ' De la man Satanaxio '—(two islands on its western verge)—that they represent Pre-Columbian discovery of South and North America." Humboldt (" Crit. Untersuchungen," I. 413, 416) has discussed the question, and pointed out that one island, " Antillia," had earlier appeared on a map of 1425, and D'Avezac finds even earlier references to the same island.

To Andrea Bianco may be ascribed the best of all known forms of wind-roses. Admiral L. Fincati illustrates, in his well-known pamphlet " Il Magnete, la Calamita e la Bussola," Rome, 1878, all the best-known examples from 1426 to 1612, those of Bianco having upon them either the *fleur de lys* (referred to at A.D. 1327–1377) or the letter T, or designs of a triangle or trident, to indicate the north, whilst the east is designated by a cross, in same manner as shown in the 1426 Giraldi and the Oliva 1612–1613.[1]

For other forms and accounts of these rose-of-the-winds or compass cards, it would be well to consult more particularly Nordenskiöld, Nils Adolf Erik (1832–1901), " Periplus " (1897), as well as his " Facsimile Atlas " published eight years previously; Pedro de Medina, " Arte de Navegar "; Francesco Da Buti, " Comment, sopra la Div. Com. "; Simon Stevin's " Haven-finding Art "; Athan. Kircher, " Magnes, sive de Arte Magnetica "; and Guillaume de Nautonniez, " Mécométrie de l'Eymant . . . déclinaison guideymant pour tous les lieux . . ." published 1602–1604.[2]

[1] In Kohl's collection of early maps already alluded to as given in " Harv. Univ. Bull.," Vol. III, reference is made (p. 175) to the portolano—A.D. 1426—of a Venetian hydrographer, Giacomo Giraldi, which has been preserved in the Biblioteca Marciana and which was reproduced at Venice by Ongania in 1881, also (p. 303) to the Map of America published during 1570 by Abraham Oertel—Ortell—*b.* 1527, *d.* 1598, and at p. 365 to the Map of the World by Joannes Oliva, A.D. 1613, as well as to an Atlas by Salvatore Oliva, A.D. 1620, showing both the Americas. In an article headed " The first true Maps," to be found in " Nature " of December 15, 1904, pp. 159–161, mention is made that the oldest dated portolan is the first of Pietro Vesconte—Visconti—executed in 1311.

[2] For Nautonniez, see Houzeau et Lancaster, " Bibl. Gén.," Vol. I. part ii. p. 1193, also J. G. T. Græsse, " Trésor de Livres Rares," Dresde, 1863, Vol. IV. p. 651, and Brunet, " Manuel," p. 827, at which latter appears the statement of M. Frère to the effect that Guillaume de Nautonnier—Nautonniez—caused to be reprinted, under the above-named title of " Mécométrie de l'Eymant," the " Dialogue de la Longitude " of Toussaincte de Bessard originally published at Rouen in 1574.

For the reported investigation of Pedro da Medina, who, Gilbert says, (" De Magnete," Book IV. chap. viii.) does not accept variation and has with many errors disgraced the art of navigation, consult, preferably, the Venetia 1555 edition entitled " L'Arte del navegar," Libro sesto, " Della Aguggia,

REFERENCES.—"Biog. Gen.," Vol. V. pp. 922–923, Mazzuchelli, "Scrittori d' Italia"; "New Int. Encycl.," New York, 1902–1903, Vol. II. p. 796; Larousse, "Dict. Univ.," Vol. II. p. 672; Humboldt, "Cosmos," 1859, Vol. V. p. 55; Johnson's "New Univ. Cycl.," 1878, Vol. III. p. 230; "Der Atlas des Andrea Bianco vom Jahre 1436 of Oscar Peschel," Venedig, 1869; Justin Winsor, "Narrative and Critical Hist. of America," Boston, 1889, Vol. I. pp. 50–56, 114, 117; "Formaleoni, saggio sulla nautica antica de Veneziani," Venez., 1783, pp. 51–59 (Libri, "Hist. des. Math.," Vol. III).

A.D. 1490–1541.—Paracelsus (Aureolus Theophrastus)—the assumed name of Philippus Aureolus Theophrastus Bombast von Hohenheim—a native of Switzerland, admitted by unprejudiced writers to have been one of the greatest chemists of his time (Hemmann, "Medico—Sur. Essays," Berlin, 1778). The author of "Isis Unveiled" states that he made use of electromagnetism three centuries before Prof. Oersted's discovery, and that he rediscovered the occult properties of the magnet, "the bone of Horus," which, twelve centuries before his time, had played such an important part in the theurgic mysteries, thus very naturally becoming the founder of the school of magnetism and of mediæval magico-theury. But Mesmer, who lived nearly three hundred years after him, and as a disciple of his school brought the magnetic wonders before the public, reaped the glory that was due to the fire-philosopher, while the great master died in want ("Isis Unveiled," Vol. I. pp. 71, 72, 164).

Madame Blavatsky further adds (Vol. I. p. 167) that the full views of Paracelsus on the occult properties of the magnet are explained partially in his famous book "Archidoxorum," wherein he describes the wonderful tincture, a medicine extracted from the magnet, and called "Magisterium Magnetis," and partially in the "De Ente Dei" and "De Ente Astrorum," lib. i.

In the words of Paracelsus, we give the following extracts concerning the loadstone, taken from "The Hermetic and Alchemical Writings . . ." by A. E. Waite, London, 1894:

Vol. I. p. 17.—"The adamant. A black crystal called . . . Evax . . . is dissolved in the blood of a goat."

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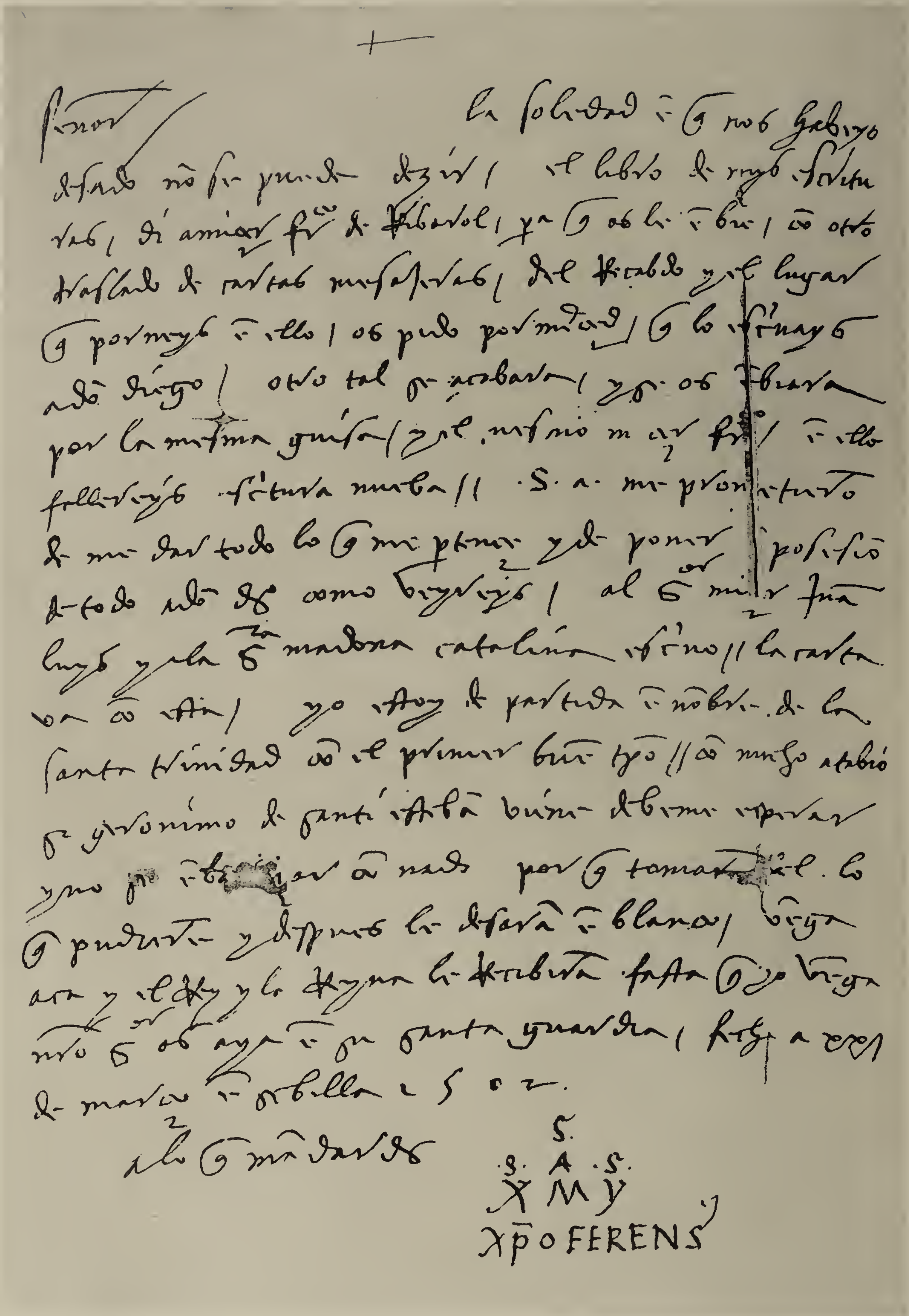
over bossolo da navegar," pp. cviii–cxvi. The leaf xxiii contains a Map of America. This last-named map of the Nuevo Mundo "may be taken to represent the results of Spanish discovery about 1540, Pedro da Medina having been the official examiner of pilots. It is interesting as showing the mouth of the Spirito Santo (the Mississippi) and the lands around the river and gulf of St. Lawrence. The Island of Cape Breton appears as part of Nova Scotia and of the mainland; but Newfoundland is represented as three islands, divided from Northern Canada by a much wider expanse of water than the actual Straits of Belle Isle. This is, however, a striking instance of the great extent of Medina's geographical knowledge. The river Saguenay is shown at its entry into the St. Lawrence, which is also a remarkable feature in so early a map."


.S.
.S. A .S.
X M Y
Xpo FERENS

Christopher Columbus. Photographic reproduction of his letter, March 21st, 1502, to Nicolo Oderigo, Ambassador to France and to Spain, which was acquired by the King of Sardinia and presented by him to the City of Genoa. It is now preserved in the Palace of the Genoese Municipality.

✠

Sir,—The loneliness in which you have left us cannot be told. I have given the book of my writings to Messer Francesco di Ribarola, in order that he may send it to you, with another transcript of letters missive. Respecting the receipt thereof, and the place in which you will put it, I beg you to be so good as to write to Don Diego. Another similar one shall be finished and sent to you in the same manner, and by the same Messer Francesco; you will find a new writing in it. Their Highnesses made me a promise to give me all that belongs to me, and to put Don Diego into possession of everything, as you will see. I am writing to Messer Gian Luigi and to the Signora my Lady Caterina; the letter is going with this one. I am on the point of setting out, in the name of the Holy Trinity, with the first fine weather, with a great equipment. If Girolamo da Santo-Stefano comes, he must wait for me, and not burden himself with anything, because they will take from him whatever they can, and will then leave him bare. Let him come hither, and the King and Queen will receive him until I arrive. May Our Lord have you in his holy keeping. Done on the 21st of March, in Seville, 1502.

At your command

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Señor,—La soledad en que nos babeys desado non se puede dezir. El libro de mys escrituras, di amiçer Françisco de Ribarol, para que os le enbie, con otro traslado de cartas mesajeras. Del recabdo y el lugar que porneys en ello, os pido por merçed que lo escrivays aDon Diego. Otro tal se acabara, y se os enbiara por la mesma guisa, y el mesmo miçer Françisco: en ello fallereys escritura nueba. Sus Altezas me prometieron de me dar todo lo que me pertençe y de poner [en] posesion de todo aDon Diego como veyreys. Al Senor mi[çe]r Juan Luys y ala Señora madona Catalina escrivo. La carta va con esta. Yo estoy de partida en nonbre de la Santa Trinidad con el primer buen tienpo, con mucho atabio. Si Geronimo de Santi Esteban viene debeme esperar y no se enb[ali]jar con nada por que tomar[a]n del lo que pudieren y despues le desaran en blanco. Venga aca y el Rey y la Reyna le recibiran fasta que yo venga. Nuestro Señor os aya en su santa guardia. Fecha a xxi de marҫo en Sebilla 1502.

Alo que mandardes.

·S·

·S· A ·S·

X M Y

Xp̄o FERENS.

Christopher Columbus. Translation of the letter written by him to Nicolo Oderigo, shown opposite; made into English by Mr. G. A. Barwick, B.A., of the British Museum. Permission to reproduce both original letter and its translation was given by Messrs. B. F. Stevens & Brown, London.

"The magnet. Is an iron stone, and so attracts iron to itself. Fortified by experience. . . . I affirm that the magnet . . . not only attracts steel and iron, but also has the same power over the matter of all diseases in the whole body of man."

Vol. I. pp. 132 and 145.—"A magnet touched by mercury or anointed with mercurial oil, never afterwards attracts iron . . . same if steeped in garlic. . . ."

Vol. I. p. 136.—"The life of the magnet is the spirit of iron which can be taken away by rectified *vinum ardens* itself or by spirit of wine."

Vol. II. p. 59.—"Wherever the magnet has grown—there, a certain attractive power exists, just as colocynth is purgative and the poppy is anodyne. . . ."

Mr. A. E. Waite says (Vol. II. p. 3) that the ten books of Paracelsus' *Archidoxies* stand in the same relation to Hermetic Medicine as the nine books *Concerning the Nature of Things* stand to Hermetic Chemistry and to the science of metallic transmutation.

References.—Biography of Paracelsus, in Larousse, "Dict Univ.," Vol. XII. pp. 171–172, in F. Hartmann, 1887, and in the ninth ed. of the "Encycl. Brit.," Vol. XVIII. pp. 234–236; Van Swinden, "Recueil," etc., La Haye, 1784, Vol. I. pp. 356–358; Gilbert, "De Magnete," Book I. chaps. i. and xiv., also Book II. chap. xxv.; "Journal des Savants" for November 1849; Walton and Cotton, "Complete Angler," New York and London, 1847, pp. 212–213, for notes regarding Paracelsus, Robert Fludd, Jacob Behmen and the Rosicrucians; "Dictionnaire Historique de la Médecine," N. F. Eloy, Mons, 1778, Vol. III. pp. 461–471; "History and Heroes of the Art of Medicine," J. Rutherfurd Russell, London, 1861, pp. 157–175; "Histoire Philosophique de la Médecine," Etienne Tourtelle, Paris, An. XII. (1804) Vol. II. pp. 326–346; "History of Magic," Joseph Ennemoser, London, 1854, Vol. II. pp. 229–241.

At p. 55 of the first supplement to "Select. Bibliog. of Chemistry," by H. C. Bolton, Washington, 1899, mention is made of the Paracelsus Library belonging to the late E. Schuberth of Frankfort-on-the-Main . . . as containing 194 titles of works on Paracelsus and 548 titles of works relating to Paracelsus and his doctrines; the section on Alchemy embracing as many as 351 titles.

A.D. 1492.—Columbus, Colombo, Colon (Christopher), the discoverer of America, is the first to determine astronomically the position of a *line of no magnetic variation* (on which the needle points to the true north) the merit of which discovery has, by Livio Sanuto, been erroneously attributed to Sebastian Cabot. (Livio Sanuto, "Geographia distincta in XII libri . . ." wherein the whole of Book I is given to reported observations of the compass and to accounts of different navigators.)

Columbus did not, as many imagine, make the first observations of the existence of magnetic variation, for this is set down upon the charts of Andrea Bianco, but he was the first who remarked, on the 13th of September, 1492, that "$2\frac{1}{2}$ degrees east of the island of

Corvo, in the Azores, the magnetic variation changed and passed from N.E. to N.W." Washington Irving thus describes the discovery ("History . . . Ch. Columbus," Paris, 1829, Vol. I. p. 198): "On the 13th of September, in the evening, being about two hundred leagues from the island of Ferro (the smallest of the Canaries), Columbus, for the first time, noticed the variation of the needle, a phenomenon which had never before been remarked. He perceived, about nightfall, that the needle, instead of pointing to the North Star, varied about half a point, or between five and six degrees to the north-west, and still more on the following morning. Struck with this circumstance, he observed it attentively for three days and found that the variation increased as he advanced. He at first made no mention of this phenomenon, knowing how ready his people were to take alarm; but it soon attracted the attention of the pilots, and filled them with consternation. It seemed as if the laws of nature were changing as they advanced, and that they were entering into another world, subject to unknown influences (Las Casas, 'Hist. Ind.,' l. i. c. 6). They apprehended that the compass was about to lose its mysterious virtues; and, without that guide, what was to become of them in a vast and trackless ocean? Columbus tasked his science and ingenuity for reasons with which to allay their terrors. He told them that the direction of the needle was not to the polar star but to some fixed and invisible point. The variation, therefore, was not caused by any fallacy in the compass, but by the movement of the North Star itself, which, like the other heavenly bodies, had its changes and revolutions, and every day described a circle around the pole. The high opinion that the pilots entertained of Columbus as a profound astronomer gave weight to his theory, and their alarm subsided."

Humboldt says: "We can, with much certainty, fix upon three places in the *Atlantic line of no declination* for the 13th of September, 1492, the 21st of May, 1496 and the 16th of August, 1498."

References.—"Columbus and his Discoveries," in the "Narrative and Critical History of America," by Justin Winsor, Boston, 1889, Vol. II. pp. 1–92; "Christopher Columbus, His life, work . . ." by John Boyd Thacher, 1903; Giov. Bat. Ramusio, "Terzo volume delle Navigationi e Viaggi . . ." 1556; Dr. Geo. Miller, "History Phil. Illust.," London, 1849, Vol. II. pp. 216–219; David Hume, "History of England," London, 1822, Vol. III. pp. 387–398; Guillaume Libri, "Histoire des Sciences Mathématiques en Italie," Halle, 1865, Vol. III. pp. 68–85; "Columbus, a Critical Study," by Henry Vignaud, London, 1903; Weld, "Hist. Royal Society," Vol. II. p. 429; Thos. Browne, "Pseudodox. Epid.," 1658, Book II. pp. 68–69; Humboldt, "Cosmos," 1849, Vol. I. p. 174; Vol. II. pp. 636, 654–657, 671–672, and Vol. V. (1859) pp. 55–56, 116; Knight, "Mech. Dict.," Vol. II., pp. 1374, 1397; Poggendorff, "Geschichte der Physik," Leipzig, 1879, p. 270; "Raccolta di documenti e studi publicati della R. Com. Columb. pel 40 Centenario

dalla scoperta dell' America," Roma, 1892; Humboldt, "Examen Critique . . . progrès de l'astronomie nautique," Paris, 1836, Vol. I. pp. 262–272, etc.

It may be worth noting here that the ashes of Columbus, removed from the Cathedral of Havana, were placed in a mausoleum at Seville, November 17, 1902 ("Science," Dec. 12, 1902, p. 958).

Amongst the numerous claimants to the discovery of America, some have placed the great navigator Martin Behaim—Behem—(1430–1506), who received his instruction from the learned John Müller (Regiomontanus) and became one of the most learned geographers as well as the very best chart maker of his age. Cellarius, Riccioli and other writers assert that Behaim had, before Columbus, visited the American Continent, while Stuvenius shows, in his treatise "De vero novi orbis inventore," that the islands of America and the strait of Magalhæns were accurately traced upon the very celebrated globe called the "World Apple" completed by Behaim in the year 1492, and which is still to be seen in Behaim's native city of Nürnberg.[1] (See Mr. Otto's letter to Dr. Franklin, in the second volume of the "Transactions of the American Philosophical Society held at Philadelphia for promoting useful knowledge," likewise Humboldt, "Examen critique de l'histoire de la Géographie," Vol. II. pp. 357–369; "The Reliquary," London, Vol. VI. N.S. Jan.–Oct. 1892, pp. 215–229; Justin Winsor, "Narrative and Critical History of America," Boston 1889, Vol. II. pp. 104–105; "Geogr. Jour.," Vol. V. March 1895, p. 228.)

It was this same Martin Behaim (Humboldt, "Cosmos," 1860, Vol. II. p. 255) who received a charge from King John II of Portugal to compute tables for the sun's declination and to teach pilots how to "navigate by the altitudes of the sun and stars." It cannot now be decided whether at the close of the fifteenth century the use of the log was known as a means of estimating the distance traversed while the direction is indicated by the compass; but it is certain that the distinguished voyager Francisco Antonio Pigafetta (1491–1534) the friend and companion of Magellan—Magalhæns—speaks of the log (*la catena a poppa*) as of a well-known means of measuring the course passed over. Nothing is to be found regarding way-measurers in the literature of the Middle Ages until we come to the period of several "books of nautical instruction," written or printed by this same Pigafetta ("Trattato di Navigazione," probably before 1530); by Francisco Falero, a brother of Ruy Falero, the astronomer ("Regimiento para observar la longitud

[1] Behaim's justly famous globe was made up from the authorities of Ptolemy, Pliny and Strabo, as well as from the reports of Marco Polo's travels and the semi-fabulous travels of Sir John Mandeville ("English Cyclopædia," Vol. I. p. 617).

en la mar," 1535); by Pedro da Medina, of Seville ("Arte de Navegar," 1545); by Martin Cortez, of Bujalaroz ("Breve Compendio de la esfera, y de la arte de navegar," 1551), and by Andres Garcia de Cespedes ("Regimiento de Navigacion y Hidrografia," 1606). From almost all these works—some of which, if not all, have naturally become very scarce—as well as from the "Summa de Geografia" which Martin Fernandez de Enciso had published in 1519, we learn most distinctly that the "distance sailed over" was then ascertained in Spanish and Portuguese ships not by any distinct measurement, but only through estimation of the eye, according to certain established principles. Medina says (lib. iii. caps. 11–12): "In order to know the course of the ship, as to the length of distance passed over, the pilot must set down in his register how much distance the vessel hath made according to hours (*i. e.* guided by the hour-glass, *ampoleta*); and, for this, he must know that the most a ship advances in an hour is four miles, and, with feebler breezes, three or only two." Cespedes, in his "Regimiento" (pp. 99 and 156) calls this mode of proceeding *echar punto por fantasia*, and he justly remarks that if great errors are to be avoided, this *fantasia* must depend on the pilot's knowledge of the qualities of his ship. Columbus, Juan de la Cosa, Sebastian Cabot and Vasco da Gama, were not acquainted with the log and its mode of application, and they all estimated the ship's speed merely by the eye, while they ascertained the distance they had made merely through the running down of the sand in the glasses known as *ampoletas*.

REFERENCES.—For F. A. Pigafetta, for Petro de Medina and for Martin Cortez, Houzeau et Lancaster, "Bibl. Génér.," Vol. I. pt. ii. pp. 1221–1223; "New Gen. Biog. Dict.," Jas. Rose, London, 1850, Vol. XI. p. 113; "Biog. Univ." (Michaud), Vol. XXXIII. p. 297; "Grand Dict. Univ." (Larousse), Vol. XII. p. 999; "Nouv Biog. Gen." (Hœfer), Vol. XL. p. 207. Also Dr. G. Hellmann's "Neudrucke," 1898, No. 10, for reproduction of Francisco Falero's "Tratato del Esphera y del arte del marear" (Del Nordestear de las Agujas), 1535, as well as for reproduction of Martin Cortez' "Breve Compendio" (De la piedra Yman), 1551.

A.D. 1497.—Gama (Vasco or Vasquez da), celebrated Portuguese navigator, is known positively to have made use of the compass during the voyage he undertook this year to the Indies. He says that he found the pilots of the Indian Ocean making ready use of the magnet. The first book of the history of Portugal by Jerome Osorius—wherein he gives (pp. 23–24, Book I. paragraph 15, 1581 ed.) a very extended "description de l'aiguille marine, invention des plus belles et utiles du monde"—states that, instead of a needle, they used a small magnetized iron plate, which was suspended like the needle ot the Europeans, but which showed imperfectly the north.

Gilbert says (" De Magnete," Book IV. chap. xiii.) that, as the Portuguese did not rightly understand the construction and use of the compass, some of their observations are untrustworthy and that in consequence various opinions exist relative to magnetic variation. For example, the Portuguese navigator Roderigues de Lazos—Lagos—takes it to be one-half point off the Island of St. Helena; the Dutch, in their nautical journal, make it one point there; Kendall, an expert English navigator, makes it only one-sixth of a point, using a true meridional compass. Diego Alfonso finds no variation at a point a little south-east of Cape das Agulhas,[1] and, by the astrolabe, shows that the compass points due north and south at Cape das Agulhas if it be of the Portuguese style, in which the variation is one-half point to the south-east.

References.—Azuni, " Boussole," p. 121; Klaproth, " Boussole," p. 64; Knight, " Mech. Dict.," Vol. II. p. 1398; Larousse, " Dict.," Vol. VIII. p. 977; " Voyageurs anciens et modernes " (Charton), 1855; " Le Comte Amiral D. Vasco da Gama," par D. Maria T. da Gama, Paris, 1902.

A.D. 1497.—Cabot (Sebastian), a prominent English navigator, lands, June 24, 1497, on the coast of Labrador, between 56 degrees and 58 degrees north latitude.

At p. 150 of the 1869 London edition of Mr. J. F. Nicholl's " Life of Seb. Cabot," it is said the latter represented to the King of England that the variation of the compass was different in many places, and was not absolutely regulated by distance from any particular meridian; that he could point to a spot of no variation, and that those whom he had trained as seamen, as Richard Chancellor and Stephen Burrough, were particularly attentive to this problem, noting it at one time thrice within a short space.

References.—Richard Hakluyt, " The Principal navigations, voyages, traffiques and discoveries of the English nation," 1599: at pp. 237–243, for the voyage of Richard Chancelor, pilote maior, and, at p. 274, for " the voyage of Steuen Burrough, master of the pinnesse called the Serchtrift "; Livio Sanuto, " Geografia," Venice, 1588, lib. i.; Fournier, " Hydrographie," lib. xi.; " Library of Am. Biog.," by Jared Sparks, Boston, 1839, Vols. II and VII as per Index at pp. 318–319; " Jean et Seb. Cabot," par Hy. Harisse, Paris, 1882; Geo. P. Winship, " The Cabot Bibliography," London and New York, 1900; Humboldt, " Examen Critique," Vol. IV. p. 231, and " Cosmos," Vol. II. (1860) pp. 640, 657–658; Biddle, " Memoir of Seb. Cabot," 1831, pp. 52–61.

A.D. 1502.—Varthema–Vertomannus (Ludovico di) leaves Europe for the Indies, as mentioned at p. 25 of his " Travels," translated by J. Winter Jones, London, 1863, from the original " Itenerario . . . ne la India . . ." Milano, 1523. He states that

[1] Aguilhas, in Portuguese, signifies needles: Walker, " Magnetism of Ships," 1853, p. 2; Sir Thomas Browne, " Pseud. Epidem.," Book II. p. 70.

the Arabs who navigated the Red Sea were known to have long since made use of the mariner's chart and compass, and he tells us, in the introduction and at p. 249, that " the captains carried the compass with the needle after our manner," and that their chart was " marked with lines perpendicular and across." When the polar star became invisible, they all asked the captain by what he could then steer them, and " he showed us four or five stars, among which there was one (*B. Hydrus*) which he said was opposite to (*contrario della*) our North Star, and that he sailed by the north because the magnet was adjusted and subjected to our north, *i. e.* because this compass was no doubt of European origin—its index pointing to the north, and being unlike that of the Chinese pointing to the south."

References.—Cavallo, " Magnetism," London, 1787, Chap. IV; also, " Hakluyt's Collection of the early voyages, travels and discoveries," London, 1811, Vol. IV. p. 547, for " The navigation and voyages of Lewes Vertomannus."

A.D. 1530–1542.—Guillen (Felipe), an ingenious apothecary of Seville, and Alonzo de Santa Cruz (who was one of the instructors of mathematics to young Charles V, King of Spain and Emperor of Germany, and the *Cosmografo Mayor* of the Royal Department of Charts at Seville), construct variation charts and variation compasses by which solar altitudes can be taken.

References.—Humboldt, " Cosmos," 1849, Vol. II. p. 658, and 1859, Vol. V. p. 56; L. A. Bauer, " U. S. Magn. Tables," 1902, p. 26.

Although based upon very imperfect observations, the magnetic charts thus devised by Alonzo de Santa Cruz antedate by more than one hundred and fifty years the work of Dr. Halley (at A.D. 1683).

A.D. 1544.—Hartmann (Georg) a vicar of the church of Saint Sebaldus, at Nuremberg, writes March 4, to the Duke Albrecht of Prussia, a letter which was brought to light by Moser and which reads as follows : " Besides, I find also this in the magnet, that it not only turns from the north and deflects to the east about nine degrees, more or less, as I have reported, but it points downward. This may be proved as follows : I make a needle a finger long, which stands horizontally on a pointed pivot, so that it nowhere inclines toward the earth, but stands horizontal on both sides; but, as soon as I stroke one of the ends (with the loadstone) it matters not which end it be, then the needle no longer stands horizontal, but points downward (*fällt unter sich*) some nine degrees, more or less. The reason why this happens I was not able to indicate to his Royal Majesty." The above seems to establish the fact that Hartmann first observed the dip of the magnetic needle independently of Robert Norman.

Gilbert refers (" De Magnete," Book I. chap. i.) to Fortunius Affaitatus—Affaydatus—an Italian physicist who, says he, has some rather silly philosophizing about the attraction of iron and of its turning to the poles, thus alluding to the latter's small work called " Physicæ (et) ac astronomiæ (astronomicæ) considerationes," which appeared at Venice in 1549. Nevertheless, it is a question whether Affaitatus was not actually the first to publish the declination of the magnetic needle. (" Biogr. Gén.," Vol. I. p. 346; Mazzuchelli, " Scrittori d'Italia "; Bertelli, " Mem. sopra P. Peregrino," p. 115; Adelung, Supplément à Jocher, " Allgem. Gelehrten-Lexicon "; Johann Lamont, " Handbuch des Magnetismus," Leipzig, 1867, p. 425; J. C. Poggendorff, " Biogr.–Lit. Handwörterbuch," Leipzig, 1863, Vol. I. p. 15; Michaud, " Biogr. Univ. Anc. et Mod.," Vol. I. p. 208, Paris, 1843; Brunet, " Manuel," Paris, 1860; " Biog. Cremonese de Lancetti "; M. le Dr. Hœfer, " Biog. Gen.," Paris, 1852, Vol. I. p. 346.)

References.—Dove, " Repertorium der Physik," Vol. II, 1838, pp 129–130; Poggendorff, " Geschichte der Physik," 1879, p. 273; L. Hulsius, " Descriptio et usus," Nürnberg, 1597; " Ency. Brit.," 1883, Vol. XV. p. 221; P. Volpicelli, " Intorno alle prime . . . magnete " (Atti dell Acad. Pont. de Nuov. Lincei, XIX. pp. 205, 210).

A.D. 1555.—Olaus Magnus, a native of Sweden and Archbishop of Upsala (where he died during 1568) issued in Rome his great work " Historia de Gentibus Septentrionalibus," which, for a long time, remained the chief authority on Swedish matters. In this book, Gilbert says (" De Magnete," lib. i. cap. 1) allusion is made to a certain magnetic island and to mountains in the north possessing such power of attraction that ships have to be constructed with wooden pegs so that as they sail by the magnetic cliffs there be no iron nails to draw out.

To this, reference is made by Thos. Browne (" Pseud. Epidem.," 1658, Book II. p. 78) as follows : " Of rocks magnetical, there are likewise two relations; for some are delivered to be in the Indies and some in the extremity of the North and about the very pole. The Northern account is commonly ascribed unto Olaus Magnus, Archbishop of Upsala, who, out of his predecessors—Joannes, Saxo and others—compiled a history of some Northern Nations; but this assertion we have not discovered in that work of his which commonly passeth among us; and should believe his geography herein no more than that in the first line of his book, where he affirmeth that Biarmia (which is not 70 degrees in latitude) hath the pole for its zenith, and equinoctial for the horizon."

In a Spanish book entitled " The Naval Theatre," by Don Francisco de Seylas and Louera, we find two causes assigned for the

variation of the declination; one is " the several mines of load-stones found in the several parts of the earth . . ." the other being that " there is no doubt but large rocks of load-stones may affect the needles when near them . . ." (" Philos. History . . . Roy. Acad. Sc. at Paris," London, 1742, Vol. II. pp. 279–280).

References.—Claudus Ptolemæus, " Geographia," lib. vii. cap. 2 (and others named by Bertelli Barnabita at foot of p. 21 of his " Pietro Peregrino de Maricourt," Roma, 1868, viz. Klaproth, " Lettre sur la Boussole," Paris, 1834, p. 116; Thos. H. Martin, " Observ. et Théor. des anciens," Rome, 1865, p. 304; Steinschneider, " Intorno. alla calamita," Roma, 1868); also Albertus Magnus, Lugduni, 1651; Mr. (Thomas) Blundeville, " His Exercises "; Fracastorio, in the seventh chapter of his " De Sympathia et Antipathia "; F. Maurolycus, " Opuscula," 1575, p. 122*a*; Lipenius, " Navigatio Salomonis Ophiritica "; Paulus Merula, " Cosmographia Generalis," Leyden, 1605; Toussaincte de Bessard, " Dialogue de la Longitude," Rouen, 1574; U. Aldrovandi, " Musæum Metallicum," 1648, pp. 554, 563, wherein he alludes to the magnetic mountains spoken of by Sir John Mandeville; Ninth " Encycl. Brit.," Vol. XVII. p. 752; also the entry at A.D. 1265–1321.

A.D. 1558.—Porta (Giambattista della), Italian natural philosopher (1540–1615), carries on a series of experiments with the magnet for the purpose of communicating intelligence at a distance. Of these experiments, he gives a full account in his " Magiæ Naturalis," the first edition of which is said to have been published at Naples when Porta was but fifteen years of age (" Encycl. Brit.," article " Optics "). Prof. Stanley Jones says this is the earliest work in which he has found allusions to a magnetic telegraph.

Porta's observations are so extraordinary—and they attracted so much attention as to justify eighteen separate editions of his work in different languages prior to the year 1600—that extracts must needs here prove interesting. They are taken out of " Natural Magick in XX Bookes by John Baptist Porta, a Neapolitaine . . . London 1658," the seventh book of which treats " Of the wonders of the loadstone."

Proem : " And to a friend that is at a far distance from us and fast shut up in prison, we may relate our minds; which I doubt not may be done by two mariner's compasses, having the alphabet writ about them . . ."

Chap. I (alluding to the loadstone) :

" The Greeks do call it *Magnes* from the place,
For that the Magnet's hand it doth embrace."

Nicander thinks the stone was so called—and so doth Pliny—from one *Magnes*, a shepherd.

In Chap. XVIII he states that " the situation makes the Vertues of the Stone contrary . . . for the stone put above the table will do one thing, and another thing if it be put under the table . . . that

part that drew above will drive off beneath; and that will draw beneath that drove off above : that is, if you place the stone above and beneath in a perpendicular."

In Chap. XXV, in allusion to "a long concatenation of iron rings," he thus quotes Lucretius :

> "A stone there is that men admire much
> That makes rings hang in chains by touch.
> Sometimes five or six links will be
> Fast joyn'd together and agree.
> All this vertue from the Stone ariseth,
> Such force it hath . . ."

Chap. XXVII alludes to the Statue hung by Dinocrates : " . . . but that is false, that Mahomet's chest hangs by the roof of the Temple. Petrus Pellegrinus saith, he shewed in another work how that might be done : but that work is not to be found . . . But I say it may be done—because I have now done it—to hold it fast by an invisible band, to hang in the air : onely so, that it be bound with a small thread beneath, that it may not rise higher : and then striving to catch hold of the stone above, it will hang in the air, and tremble and wag itself."

In Chap. XXVIII he says that "Whilst the loadstone is moved under a table of wood, stone or any metal, except iron, the needle in the mariner's compass will move above, as if there is no body between them. St. Augustine ('Liber de Civitate Dei') knew this experiment (likewise alluded to by Camillus Leonardus in his 'Speculum Lapidum,' published 1502). But that is much more wonderful that I have heerd : that if one hold a loadstone under a piece of silver, and put a piece of iron above the silver, as he moves his hand underneath that holds the stone, so will the iron move above; and the silver being in the middle, and suffering nothing, running so swiftly up and down, that the stone was pulled from the hand of the man, and took hold of the iron."

Chap. XXX is headed : "A loadstone on a plate of iron, will not stir iron," and he again quotes Lucretius :

> "Pieces of iron I have seen
> When onely brass was put between
> Them and the Loadstone, to recoil :
> Brass in the middle made this broil."

In Chap. XXXII he tells us that an Italian "whose name was Amalphus . . . knew not the Mariner's Card, but stuck the needle in a reed, or a piece of wood, cross over : and he put the needles into a vessel full of water that they might flote freely : then carrying about the loadstone, the needles would follow it : which being taken away, as by a certain natural motion, the points of the needles would turn

to the north pole : and, having found that, stand still . . . Now the Mariner's Compass is made, and a needle touched with the Loadstone, is so fitted to it, that, by discovering the pole by it, all other parts of the heavens are known. There is made a rundle with a Latin-navel upon a point of the same metal, that it may run roundly freely. Whereupon, by the touching onely of one end, the needle not alone partakes of the vertues of it, but of the other end also, whether it will or not . . ."

Chap. XLVIII is headed "Whether Garlick can hinder the vertues of the loadstone." By Porta we are informed that "Plutarch saith Garlick is at great enmity with the loadstone; and such antipathy and hatred there is between these invisible creatures, that if a loadstone be smeered with Garlick, it will drive away iron from it," which is confirmed by Ptolemy, who states "that the loadstone will not draw iron, if it be anoynted with Garlick; as Amber will no more draw straws, and other light things to it, if they be first steeped in oyl." He found that when the loadstone "was all anoynted over the juice of Garlick, it did perform its office as well as if it had never been touched with it."

In Chap. LIII Porta denies "that the diamond doth hinder the loadstone's vertue." "Some pretend," says he, "there is so much discord between the qualities of the loadstone and the diamond, and they are so hateful, one against the other, and secret enemies, that if the diamond be put to the loadstone, it presently faints and loses all its forces. (Pliny.) The loadstone so disagreeth with the diamond, that if iron be laid by it, it will not let the loadstone draw it; and if the loadstone do attract it, it will snatch it away again from it. (St. Augustine.) I will say that I have read of the loadstone : how that, if the diamond be by it, it will not draw iron; and, if it do when it comes neer the diamond, it will let it fall" (Marbodeus, of the Loadstone . . . Marbodei Galli . . . de lapidibus pretiosis Enchiridion . . . Freiburg, 1530, 1531) :

> "All loadstones by their vertue iron draw;
> But of the diamond it stands in awe :
> Taking the iron from't by Nature's Law."

"I tried this often, and found it false; and that there is no truth in it."

With reference to the above, see Plat (at A.D. 1653), who also alludes to the fact of the softening of the diamond with Goat's blood. This is alluded to by Porta in the next chapter.

Chapter LIV contains extracts from Castianus in Geoponic. Græc., Marbodeus and Rhenius, the interpreter of Dionysius.

In 1560 there was established at Naples, by the versatile Giam.

della Porta, the first Academy of Sciences—Academia Secretum Naturæ—to which were admitted only those who had contributed to the advancement of medicine or to scientific studies in general (" Science," December 19, 1902, p. 965).

REFERENCES.—Libri, " Hist. des Sc. Mathém." Vol. IV. pp. 108–140, 399–406; Houzeau et Lancaster, Vol. II. p. 229; The Fourth Dissertation of the " Encycl. Brit.," p. 624; Sarpi, at A.D. 1632; Poggendorff, " Geschichte der Physik," 1879, pp. 133, 273–274; " Encycl. Brit.," the article on " Optics "; " Journal des Savants " for September 1841.

A.D. 1575–1624. — Boehm — Böhme — Behmen (Jacob), a mystical German writer, known as the theosophist *par excellence*, is the author of " Aurora," etc. (1612), " De Tribus Principiis " (1619) and of many other treatises, which were reprinted under the title of " Theosophia Revelata," and which contain his many very curious observations concerning astrology, chemistry, theology, philosophy and electricity.

REFERENCES.—" Notice sur J. Boehm," La Motte-Fouqué, 1831; " Notes and Queries " for July 28, 1855, p. 63; Ninth " Britan.," Vol. III. p. 852; J. Ennemoser, " History of Magic," Vol. II. pp. 297–328.

A.D. 1576.—Norman (Robert), a manufacturer of compass needles at Wapping, is the first who determined the *dip or inclination* to the earth of the magnetic needle in London, by means of a dipping needle (inclinatorium) of his own making. Five years later (1581) Norman publishes a pamphlet " The Newe Attractive, containing a short discourse of the Magnes or Lodestone, and amongest other his vertues, of a newe discouered secret, and subtill propertie concernyng the Declinyng of the Needle, touched therewith, under the Plaine of the Horizon . . ." from which is taken the following:

" Hauing made many and diuers compasses and using alwaies to finish and end them before I touched the needle, I found continuallie that after I had touched the yrons with the stone, that presentlie the north point thereof woulde bend or decline downwards under the horizon in some quantitie; in so much that to the flie of the compass, which was before levell, I was still constrained to put some small piece of ware on the south point and make it equall againe . . ." (Weld, " History of the Royal Society," 1848, Vol. II. p. 432).

In the fourth chapter of his work, Norman describes the mode of making the particular instrument with which he was enabled to establish the first accurate measurement of the dip " which for this citie of London, I finde, by exact obseruations to be about 71 degrees 50 mynutes."

Whewell thus alludes to several investigations in the same line:

"Other learned men have, in long navigations, observed the differences of magnetic variations, as Thomas Hariot, Robert Hues, Edward Wright, Abraham Kendall, all Englishmen: others have invented magnetic instruments and convenient modes of observation such as are requisite for those who take long voyages, as William Borough, in his book concerning the variation of the compass; William Barlo, in his 'Supplement'; Robert Norman, in his 'Newe Attractive.' This is that Robert Norman (a good seaman and an ingenious artificer) who first discovered the *dip* of magnetic iron" ("Enc. Metr.," p. 738; read also paragraph 366 of J. F. W. Herschel's "Prelim. Disc.," 1855).

In Book I. chap. i. of Gilbert's "De Magnete," he says that Norman posits a point and place toward which the magnet looks but whereto it is not drawn: toward which magnetized iron, according to him, is collimated but which does not attract it. He alludes again to this "respective point" (Book IV. chaps. i. and vi.), saying that Norman originated the idea of the "respective point" looking, as it were, toward hidden principles, and held that toward this the magnetized needle ever turns, and not toward any attractional point: but he was greatly in error, albeit he exploded the ancient false opinion about attraction. Gilbert then proceeds to show how this theory is proved by Norman. The original passage in Norman's "Newe Attractive" (London, 1581, Chap. VI) is as follows:

"Your reason towards the earth carrieth some probabilitie, but I prove that there be no *Attractive*, or drawing propertie in neyther of these two partes, then is the *Attractive* poynt lost, and falsly called the poynt *Attractive*, as shall be proved. But because there is a certain poynt that the needle alwayes respecteth or sheweth, being voide and without any *Attractive* propertie: in my judjment this poynt ought rather to bee called the poynt *Respective*. . . . This poynt *Respective*, is a certayne poynt, which the touched needle doth always *Respect* or shew. . . ."

For the means of determining the *dip or inclination*, see "English Ency."—Arts and Sciences—Vol. VIII. p. 160.

We have thus far learned that the *declination or variation* was alluded to by Peter Peregrinus (A.D. 1269) in the Leyden MS.; that Norman was the first to determine the *dip or inclination*, and we shall, under the 1776 date, find that Borda determined the third magnetic element called the *intensity*.

In 1581 appeared "The newe attractive . . . a discours of the variation of the cumpas . . . made by W. B(orough)." This was followed, in 1585 and in 1596, by "The newe Attractive . . . newly corrected and amended by M. W. B.," also, in 1614, by

"The New Attractive, with the application thereof for finding the true variation of the compass, by W. Burrowes."

Norman is also the author of "The safegarde of Saylers, or Great Rutter . . . translated out of Dutch . . . by R. Norman," 1590, 1600, 1640.

REFERENCES.—Noad, "Manual of Electricity," London, 1859, p. 525; Gassendi, at A.D. 1632; Humboldt, "Cosmos," 1859–1860, Vol. I. p. 179; Vol. II. pp. 281, 335; Vol. V. p. 58; Geo. Hartmann, A.D. 1543–1544; "Nature," Vol. XIII. p. 523; Walker, "Magnetism," p. 146, and, for a photo reproduction of the title-page to the 1581 edition as well as a copy of its contents, see G. Hellmann "Neudrucke . . ." 1898, No. 10; also Sidney Lee, "Dict. of Nat. Biogr.," Vol. XLI. p. 114, and William Whiston (1667–1752), "The Longitude and Latitude, discovered by the Inclinatory or Dipping Needle," London, 1721.

A.D. 1580.—The celebrated naturalist Li-tchi-tchin, who finished his *Pen-thsao-Kang-Mou* towards the end of 1580, says: "If the loadstone was not in love with iron it would not attract the latter." Eight and a half centuries before, about the year A.D. 727, the same allusion had been made by Tchin-Thsang-Khi in his "Natural History" (Klaproth, "Lettre à M. de Humboldt . . ." Paris, 1834, p. 20).

A.D. 1580.—In Parke's translation of the "History of the Kingdom of China," written by Juan G. de Mendoza, a Spanish missionary sent to the Chinese Empire by Philip II, appears the following (Vol. II. p. 36): "The Chinos doo gouerne their ships by a compasse deuided into twelue partes and doo vse no sea cardes, but a briefe description of Ruter (Ruttier—Routier—direction book) wherewith they do nauigate or saile."

A.D. 1581.—Burrowes—Borough—Burroigh (William), "a man of unquestionable abilities in the mathematiques," Comptroller of the English navy in the reign of Elizabeth, who has been alluded to as Robert Norman, is the first in Europe to publish well authenticated observations upon the magnetic variation or declination made by him from actual observation, while voyaging between the North Cape of Finmark and Vaigatch (Vaygates). These are recorded at length in his little book dedicated to "the travaillers, sea-men and mariners of England" and entitled "A Discourse of the Variation of the Cumpas, or Magneticall Needle. Wherein is Mathematically shewed, the manner of the observation, effects, and application thereof, made by W. B. And is to be annexed to The Newe Attractive of R. N. 1581 (London)."

At pp. 7 and 8 of his "Terrestrial and Cosmical Magnetism," Cambridge, 1866, Mr. Walker gives extracts from the twelve chapters of Burrowes' work which, "containing, as it does, the first recorded

attempt at deducing the declination of the needle from accurate observations, must be considered as making an epoch in the history of terrestrial magnetism."

REFERENCES.—Johnson, "New Univ. Encycl.," 1878, Vol. III. p. 230, and the tables of the variations at pp. 274–275 of Vol. II. of Cavallo's "Elements of Natural Philosophy," 1825. See the photo reproduction of "A Discourse . . ." 1596 ed. in G. Hellmann's "Neudrucke . . ." 1898, No. 10.

A.D. 1585.—Juan Jayme and Francisco Galli made a voyage from the Phillipines to Acapulco, solely for the purpose of testing by a long trial in the South Sea a declinatorium of Jayme's invention, from which M. de Humboldt says ("Cosmos," 1859, Vol. V. p. 56) some idea may be formed of the interest excited in reference to terrestrial magnetism during the sixteenth century.

A.D. 1586.—Vigenere (Blaise de), in his annotations to Livy ("Les cinq premiers livres de Tite-Live," Paris, 8vo, Vol. I. col. 1316) alludes to the possibility of communicating the contents of a letter through a thick stone wall by passing a loadstone over corresponding letters circumscribing the compass needle.

REFERENCES.—"Emporium of Arts and Sciences," Vol. I. p. 302; Fahie, p. 20.

A.D. 1589.—Acosta (Joseph d'), learned Jesuit, who has been already mentioned under the A.D. 121 entry, says in Chap. XVII. lib. i. of his masterly "Historia Natural de las Indias" ("Histoire Naturelle et Moralle des Indes tant Orientalles qu'Occidentalles," traduite par Robert Reynault Cauxois, 1598, 1606) that he is able to indicate four lines of no variation (instead of one only discovered by Columbus) dividing the entire surface of the earth: "foure poyntes in all the world, whereas the needle looked directly towards the North." Humboldt remarks that this may have had some influence on the theory advanced, in 1683, by Halley, of four magnetic poles or points of convergence.

REFERENCES.—Humboldt, "Cosmos," 1859–1860, Vol. I. pp. 66, 193, note; Vol. II. pp. 280, 281; Vol. V. p. 140.

A.D. 1590.—Cæsare (Giulio-Moderati), a surgeon of Rimini, observes the conversion of iron into a magnet by position alone. This effect was noticed on a bar which had been used as a support to a piece of brickwork erected on the top of one of the towers of the church of St. Augustine as is mentioned at the 1632 entry of Pietro Sarpi.

A.D. 1597.—Barlowe—Barlow (William)—who died May 25, 1625, and was Archdeacon of Salisbury—publishes his "Navigators'

Supply," from which the following is extracted: "Some fewe yeares since, it so fell out that I had severall conferences with two East Indians which were brought into England by Master Candish (Thomas Cavendish, one of the great navigators of the Elizabethan Age) and had learned our language. . . . They shewed that in steade of our compas they (in the East Indies) use a magneticall needle of sixe ynches long . . . upon a pinne in a dish of white *china* earth filled with water; in the bottome whereof they have two crosse lines for the foure principall windes, the rest of the divisions being reserved to the skill of their pilots."

Barlowe also published in 1613, 1616 and 1618 different editions of his work on the magnet, the full title of the last named being "Magneticall Advertisements or diuers pertinent obseruations and approued Experiments concerning the nature and properties of the Load-stone. Whereunto is annexed a briefe Discoverie of the idle Animadversions of Mark Ridley, Dr. in Physike upon this treatize."[1] Therein (Preface to the reader), he speaks of "That wonderful propertie of the body of the whole earth called the magneticall vertue (most admirably founde out and as learnedly demonstrated by Doctor Gilbert, physitian vnto our late renowned soveraigne Queen Elizabeth of happy memory) is the very true fountaine of all magneticall knowledge. So that although certain properties of the load-stone were knowne before, yet all the reasons of those properties were vtterly vnknowne and never before revealed (as I take it) vnto the sonnes of man. . . ." Just before the Preface appears the following letter which (as William Sturgeon remarks) affords a good idea of the opinion entertained by Gilbert of Barlowe's talents in this branch of science: "To the Worshipfull, my good friend, Mr. William Barlow, at Easton by Winchester. Recommendations with many thanks for all your paines and courtesies, for your diligence and enquiring, and finding diuers good secrets, I pray proceede with double capping your Loadstone you speake of, I shall bee glad to see you, as you write, as any man. I will haue any leisure, if it were a moneth, to conferre with you, you haue shewed mee more,—and brought more light than any man hath done. Sir, I will commend you to my L. of Effingham, there is heere a wise learned man, a Secretary of Venice, he came sent by that State, and was honourably receiued by her Majesty, he brought me a lattin letter from a Gentleman of Venice that is very well learned, whose name is Iohannes Franciscus Sagredus, he is a great Magneticall man and writeth that hee hath conferred with diuers

[1] It is in the "Epistle Dedicatorie" to this work that Barlowe is shown to have been the first to make use of the word *magnetisme*.

learned men of Venice, and with the Readers of Padua, and reporteth wonderfull liking of my booke, you shall haue a coppy of the latter : Sir, I purpose to adioyne an appendix of six or eight sheets of paper to my booke after a while, I am in hand with it of some new inuentions, and I would haue some of your experiments, in your name and inuention put into it, if you please, that you may be knowen for an augmenter of the art. So far this time in haste I take my leaue the XIII of February. Your very louing friend, W. GILBERT."

Speaking of William Barlowe, Anthony à Wood says : "This was the person who had knowledge of the magnet twenty years before Dr. Will. Gilbert published his book of that subject, and therefore by those that knew him he was accounted superior, or at least equal, to that doctor for an industrious and happy searcher and finder out of many rare and magnetical secrets" ("Athenæ Oxonienses," London, 1813, Vol. II. p. 375). Under heading of Gilbert, the "British Museum Catalogue of Printed Books," 1888, has it that "Mag. Adv." was compiled partly from "De Magnete."

REFERENCES.—Mark Ridley, "Magn. Animad.," 1617, p. xi; Cavallo, "Magnetism," 1787, p. 46; A.D. 1302; Sidney Lee, "Dict. of Nat. Biogr.," Vol. III. pp. 233–234; "La Grande Encycl." (H. Lamisault), Vol. V. p. 430; Pierre Larousse, "Grand Dict. Univ. du xix[e] siècle," Paris, 1867, Vol. II. p. 239; Claude Augé, "Le Nouveau Larousse," Vol. I. p. 738; "Wood's Ath. Ox." (Bliss), Vol. II. p. 375; Hœfer, "Nouv. Biogr. Univ.," Vol. IV. p. 53; "Biogr. Britannica"; Hutton, "Mathem. Dict."; "British Annual," I.

A.D. 1599.—Wright (Edward), English mathematician, connected with the East India Company and author of the Preface to Gilbert's original "De Magnete," published in London "Die Havenvinding—The Haven-finding Art : Translation of Simon Stevinus' 'Portuum investigandorum ratio,'" in which is urged the advantage of keeping registers of the variations observed on all voyages. Thus, says Lardner, the *variation of the variation* not only as to time, but as to place, had at this period begun to receive the attention of those engaged in navigation.

Wright constructed for Prince Henry a large sphere which represented the motion of the planets, moon, etc., and he predicted the eclipses for seventeen thousand one hundred years. He is said to have discovered the mode of constructing the chart which is known by the name of Mercator's Projection.

Simon Stevinus, above mentioned, also called Stephanus—Simon of Bruges—was a most distinguished mathematician and physicist (1548–1628), and is alluded to by Edward Wright not only in the Preface to Gilbert's "De Magnete" above referred to, but also in Book IV. chap. ix. of the latter work The English translation of "Portuum investigandorum ratio" was afterwards attached to

the third edition of Wright's "Certaine errors in navigation detected and corrected."

REFERENCES.—"English Cycl.," Vol. VI. p. 834; "Biogr. Génér.," Vol. XLIV. pp. 496–498; Larousse, "Dict.," Vol. XIV. p. 1100; G. Hellmann, "Neudrucke . . ." 1898, No. 10; "Chambers' Encycl.," 1892, Vol. IX., p. 725; "La Grande Encycl.," Vol. XXX. pp. 489–490; Montucla, "Hist. des Mathém.," Paris, An. VIII. Vol. II; Quetelet, also Van de Weyer, "Simon Stevin," 1845; "Mémoires de l'Académie," Paris, 1753, p. 275; Steichen, "Vie et Travaux de S. Stevin," 1846; "Terrestrial Magnetism," Vol. I. p. 153, and Vol. II. pp. 37, 72, 78.

A.D. 1599.—Pancirollus (Guido)—Panciroli (Gui)—already quoted at A.D. 121, further remarks: "The ancients sailed by the pole star, which they call *Cynosura*. The compass is believed to have been found at Amalfi, about 300 years ago by one Flavius. And this unknown fellow (if it was Flavius) hath deserved more than 10,000 Alexanders and as many Aristotles. . . . This single act hath improved knowledge and done more good to the world than all the niceties of the subtle schools."

REFERENCES.—"History of Things Lost," London, 1715, Vol. II. p. 338; Græsse, Vol. V. p. 117; also his biography in Larousse, "Dict. Univ.," Vol. XII. p. 108, and in the "Dict. de Biographie," Vol. II. p. 2012.

A.D. 1600.—Schwenter (Daniell), Professor of Oriental languages at Altdorff, describes, under the assumed name of Janus Hercules de Sunde, in his "Steganologia et Steganographia," the means of communicating intelligence at a distance by employing two compass needles circumscribed with an alphabet, the needles being shaped from the same piece of steel, and magnetized by the same magnets.

Under caption "The First Idea of the Electric Telegraph," the following appeared in the "Journal of the Franklin Institute," Vol. XXI. 1851, p. 202: "In the number of the *Philosophical Magazine* for May, 1850, I [N. S. Heineken] observe that Prof. Maunoir claims, for his friend Dr. Odier, the first idea of the electric telegraph. I herewith send you a translation of 'How two people might communicate with each other at a distance by means of the magnetic needle,' taken from a German work by Schwenter, entitled 'Deliciæ Physico-Mathematicæ,' and published at Nürnberg in 1636 . . . upward of a century before the period alluded to by Prof. Maunoir. Indeed, Oersted's grand discovery was alone wanting to perfect the telegraph in 1636. The idea, in fact, appears to have been entertained prior even to this date, for Schwenter himself quotes, at p. 346, from a *previous* author." This "previous author" is either Giambattista della

Porta, mentioned at A.D. 1558, or Famianus Strada, who appears herein under the A.D. 1617 date.

The passage from Dr. Louis Odier's letter relative to an electric telegraph is given at A.D. 1773 (see J. J. Fahie, "A History of Electric Telegraphy to the Year 1837," London, 1884, pp. 21–22).

A.D. 1600.—Gilbert—Gilberd—Gylberde (William), of Colchester (1544–1603), physician to Queen Elizabeth and to James I of England, justly called by Poggendorff "The Galileo of Magnetism," publishes his "*De magnete, Magneticisque Corporibus, et de Magno magnete tellure; Physiologia nova, plurimis et argumentis et experimentis demonstrata,*" to which he had given "seventeen years of intense labour and research"[1] and which he dedicates "alone to the true philosophers, ingenuous minds, who not only in books but in things themselves look for knowledge," and wherein the phenomena of electricity are first generalized and classified.

This great work is subdivided into six books, which respectively treat of the loadstone, of magnetic movements (*coitio*), of direction (*directio*), of variation (*variatio*), of declination (*declinatio*), and of the great magnet, the earth[2] of circular movement (*revolutio*).

Book I

After Gilbert has given in this Book an account of ancient and modern writings on the loadstone,[3] he indicates exactly what the latter is, where found, its different properties, and, having introduced

[1] "Imperial Dict. of Universal Biography," Vol. II. p. 626.

[2] The earth itself is a magnet according to Gilbert, who considered that the inflections of the lines of equal declination and inclination depend upon the distribution of mass, the configuration of continents, or the form and extent of the deep, intervening ocean basins. It is difficult to connect the periodic variations which characterize the three principal forms of magnetic phenomena (the isoclinic, the isogonic and the isodynamic lines) with this rigid system of the distribution of force and mass, unless we represent to ourselves the attractive force of the material particles modified by similar periodic changes of temperature in the interior of the terrestrial planet. . . . Of these lines, the isogonic are the most important in their immediate application to navigation, whilst we find from the most recent views that the isodynamic, especially those which indicate the horizontal force, are the most valuable elements in the theory of terrestrial magnetism (Humboldt, "Cosmos," 1859–1860, Vol. I. pp. 180–181, 185; Vol. II. p. 334, wherein references are made to Gauss, "Resultate der Beob. des Magn. Vereins," 1838, s. 21; Sabine, "Report on the Variations of the Magnetic Intensity," p. 63).

[3] The reader is referred to Appendix I herein for "Accounts of early writers and others alluded to in Gilbert's 'De Magnete,' not already disposed of throughout this Bibliographical History." Gilbert says that only a few points touching the loadstone are briefly mentioned by Marbodeus Gallus, Albertus, Mattæus Silvaticus, Hermolaus Barbarus, Camillus Leonhardus, Cornelius Agrippa, Fallopius, Joannes Langius, Cardinal de Cusa, Hannibal Rosetius Calaber, all of whom repeat only the figments of others.

us to his *terrella-microge,* or little earth[1]—a globular loadstone, showing that it has poles answering to the earth's poles, he tells us all about iron ore, its natural and acquired poles, the medicinal virtues attributed by the ancients to iron as well as to the loadstone; and he ends this First Book with the announcement that loadstone and iron ore are the same, that iron is obtained from both, like other metals from their ores, and that all magnetic properties exist, though weaker, both in smelted iron and in iron ore; furthermore, that the terrestrial globe is magnetic and is a loadstone; and that just as in our hands the loadstone possesses all the primary powers (forces) of the earth, so the earth, by reason of the same potencies, lies ever in the same direction throughout the universe.

Book II

The justly famous Second Book contains Gilbert's electrical work and, as is generally known, the second chapter thereof is the earliest ever published on electricity. We are here introduced to Gilbert's *versorium*—a rotating needle electroscope[2]—and are given the results of his many experimental observations[3] and the opinions of others relative to magnetic coition or attraction. We find, throughout the whole of the second chapter, the first systematic study of amber, with an interesting list of electrics and the recognition of a group of anelectrics—non-electrics. After pointing out the different kinds of attractions admitted by Galen and other ancient writers, we are told that:

[1] Sir Kenelm Digby ("Treatise of the Nature of Bodies," 1645, Chap. XX. p. 225) says that the manner in which Gilbert "arrived to discover so much of magnetical philosophy" and "all the knowledge he got on the subject, was by forming a little loadstone into the shape of the earth. By which means he composed a wonderful designe, which was to make the whole globe of the earth maniable; for he found the properties of the whole earth in that little body . . . which he could manage and try experiments upon at his will . . ." In the note at p. 47 (P. Peregrinus, A.D. 1269), it will be seen that the *terrella* was constructed by both in practically the same manner: only Peregrinus considered it "a likeness to the heavens," whilst Gilbert regarded it as the earth itself.

[2] The magnetized versorium consisted of a piece of iron, or needle, resting upon a point, or pin, and was put in motion, excited, by the loadstone or natural magnet. The non-magnetized versorium was made of any sort of metal, for use in electrical experiments ("De Magnete," Book II. chap. ii.; Book III. chap. i.).

[3] Asterisks. As Gilbert remarks in his Author's Preface, he has set over against "the great multitude" of his discoveries and experiments larger and smaller asterisks according to their importance and their subtility; all of his experiments having been, says he, "investigated and again and again done and repeated under our eyes." There are, in all, 178 small and 21 large asterisks, some of them being attached to illustrations, of which latter there are as many as 84 throughout the work. See Appendix II herein.

"Only feeble power of attraction is possessed by some electrics (all which have their own distinct effluvia) in favouring dry atmosphere: observable in midwinter while the atmosphere is very cold, clear and thin, when the electric effluvia of the earth offer less impediment and electric bodies are harder—that these bodies then draw, as well, all metals, wood, leaves, stones, earths, even water and oil, in short, whatever things appeal to our senses or are solid.

"All bodies are attracted by electrics, save those which are afire or flaming or extremely rarefied.

"Very many electric bodies do not attract at all, unless they are first rubbed. An ordinary piece of amber does not attract by heat, even when brought to the flaming point, but it attracts by friction, without which latter few bodies give out their true natural electric emanation and effluvium. By friction, the amber is made moderately hot and also smooth; these conditions must in most cases concur; but a large polished piece of amber or of jet attracts even without friction, though not so strongly; yet, if it be carefully brought nigh to a flame or a red coal, it does not attract corpuscles; further, the sun's heat heightened by means of a burning-glass imparts no power to amber, for it dissipates and spoils all the electric effluvia. Again, flaming sulphur and burning sealing-wax (of lac) do not attract.

"The loadstone, though susceptible of very high polish, has not the electric attraction. The force does not come through the lustre proceeding from the rubbed and polished electric; for the vincentina, diamond and pure glass attract when they are rough. Effluvia that attract but feebly when the weather is clear produce no motion at all when it is cloudy. For the effluvium from rock crystal, glass, diamond—substances very hard and very highly compressed—there is no need of any notable outflow of substance. Such an electric as sound cypress-wood, after a moment's friction, emits powers subtle and fine, far beyond all odours; but sometimes an odour is also emitted by amber, jet, sulphur, these bodies being more readily resolved; hence it is that, usually, they attract after the gentlest friction because their effluvia are stronger and more lasting.

"Rock crystal, mica, glass, and other electric bodies do not attract if they be burned or highly heated, for their primordial humour is destroyed by the heat, is altered, is discharged as vapour. All bodies that derive their origin principally from humours and that are firmly concreted attract all substances whether humid or dry; but bodies consisting mostly of humour and not firmly compacted by nature, wherefore they do not stand friction but either fall to pieces or grow soft or are sticky, do not attract corpuscles.

"Electrical movements come from the matter (*materia*) but

magnetic from the prime form (*forma*). Moist air blown from the mouth, moisture from steam, or a current of humid air from the atmosphere chokes the effluvium. But olive oil that is light and pure does not prevent it; and, if a sheet of paper or a linen cloth be interposed, there is no movement. But loadstone, neither rubbed nor heated, and even though it be thoroughly drenched with liquid, and whether in air or water, attracts magnetic bodies, and that though solidest bodies or boards or thick slabs of stone or plates of metal stand between.

"Electrics attract all things save flame and objects aflame, and thinnest air . . . for it is plain that the effluvia are consumed by flame and igneous heat . . . yet they draw to themselves the smoke from an extinguished candle; and, the lighter the smoke becomes as it ascends, the less strongly is it attracted, for substances that are too rare do not suffer attraction."

This Chapter II ends with the following explanation of the difference between electric and magnetic bodies, viz. all magnetic bodies come together by their joint forces (mutual strength); electric bodies attract the electric only, and the body attracted undergoes no modification through its own native force, but is drawn freely under impulsion in the ratio of its matter (composition). Bodies are attracted to electrics in a right line toward the centre of electricity: a loadstone approaches another loadstone on a line perpendicular to the circumference only at the poles, elsewhere obliquely and transversely, and adheres at the same angles. The electric motion is the motion of conservation of matter; the magnetic is that of arrangement and order. The matter of the earth's globe is brought together and held together by itself electrically. The earth's globe is directed and revolves magnetically; it both coheres, and, to the end it may be solid, it is in its interior fast joined.

Of the other interesting chapters in this Book II, attention is called more particularly to:

Chap. IV. "Of the strength of a loadstone and its form: the cause of coition." The magnetic nature is proper to the earth and is implanted in all its real parts . . . there is in the earth a magnetic strength or energy (*vigour*) of its own . . . thus we have to treat of the earth, which is a magnetic body, a loadstone. An iron rod held in the hand is magnetized in the end where it is grasped and the magnetic force travels to the other extremity, not along the surface only but through the inside, through the middle. . . . Iron instantly receives from the loadstone verticity and natural conformity to it, being absolutely metamorphosed into a perfect magnet. As soon as it

comes within the loadstone's sphere of influence it changes instantly and has its form renewed, which before was dormant and inert, but now is quick and active.

Chaps. VI and XXVII illustrate the *Orbis Virtutis* (Orb of Virtue, or the magnetic atmosphere surrounding both earth and loadstone alike), showing how the earth and loadstone conform magnetic movements, the centre of the magnetic forces of the earth being the earth's centre and in the terrella the terrella's centre. All loadstones alike, whether spherical or oblong, have the selfsame mode of turning to the poles of the world . . . whatever the shape, verticity is present and there are poles.

Chap. VII. "Of the potency of the magnetic force, and of its spherical extension." The magnetic energy is not hindered by any dense or opaque body, but goes out freely and diffuses its force every whither : in the case of the terrella, and in a spherical loadstone, it extends outside the body in a circle, but, in the case of an oblong loadstone, it extends into an area of form determined by the shape of, and is everywhere equidistant from, the stone itself.

Chap. XIII. "Of the magnetic axis and poles."

Chap. XV. "The magnetic force imparted to iron is more apparent in an iron rod than in an iron sphere or cube, or iron in any other shape."

Chap. XVI. "Motion is produced by the magnetic force through solid bodies interposed : of the interposition of a plate of iron."

Chaps. XVII–XXII. Herein are detailed as many as twelve different experiments to prove the increased efficiency of armed loadstones.

Chap. XXV. "Intensifying the loadstone's forces." Magnetic bodies can restore soundness (when not totally lost) to magnetic bodies, and can give to some of them powers greater than they originally had; but to those that are by their nature in the highest degree perfect, it is not possible to give further strength.

Chap. XXVIII. "A loadstone does not attract to a fixed point or pole only, but to every part of a terrella, except the equinoctial line."

Chap. XXIX. "Of differences of forces dependent on quantity or mass." Four experiments.

Chaps. XXXVIII and XXXIX are the last, and they treat of the attractions of other bodies and of mutually repellant bodies. All electrics attract objects of every kind : they never repel or propel.

In the preceding Chapter XXXV, Gilbert had alluded to the perpetual-motion engine actuated by the attraction of a

loadstone, which we have given an account of at Peter Peregrinus, A.D. 1269.

Book III

In this Third Book, we learn of the directive (or versorial) force which is called *verticitas*—verticity—what it is, how it resides in the loadstone, and how it is acquired when not naturally produced; how iron acquires it and how this verticity is lost or altered; why iron magnetized takes opposite verticity; of magnetizing stones of different shapes; why no other bodies save the magnetic are imbued with verticity by friction with a loadstone and why no body which is not magnetic can impart and awaken that force; of disagreements between pieces of iron on the same pole of a loadstone, and how they may come together and be conjoined; that verticity exists in all smelted iron not excited by the loadstone, as shown by its lying, being placed—or, preferably, by hammering hot iron—in the magnetic meridian; that the magnetized needle turns to conformity with the situation of the earth; of the use of rotary needles and their advantages; how the directive iron rotary needles of sundials and the needles of the mariner's compass are to be rubbed with loadstone in order to acquire stronger verticity.

Book IV

The Fourth Book treats of the variation at different places; says that it is due to inequality among the earth's elevations;[1] shows that variation and direction are due to the controlling force of the earth and the rotatory magnetic nature, not by an attraction or a coition or by other occult cause; explains the different modes of constructing the mariner's compass, in vogue at the time,[2] and how the deviation of the needle is greater or less according to the distance of place.

Book V

In this Fifth Book is to be found everything relative to the dip of the magnetic needle, likewise the description of an instrument for showing, by the action of a loadstone, the degree of dip below the horizon in any latitude; and the announcement that the magnetic

[1] Humboldt, "Cosmos," 1849, Vol. I. p. 170, and Vol. II. pp. 717–718.

[2] Sir Wm. Thomson, "Good Words," 1879, p. 445.

We have already indicated several modes of construction, notably at A.D. 1282 (Baïlak of Kibdjak), at A.D. 1558 (G. B. Porta), as well as at A.D. 1597 (Wm. Barlowe), and it is interesting to observe how all these vary, more particularly from the types described by Levinus Lemnius in the "De Occulta Naturæ Miracula," mentioned at B.C. 1033, and by Martinus Lipenius in his "Navigatio Salomonis Ophiritica" noted at A.D. 1250.

force is animate or imitates a soul; in many respects, it surpasses the human soul while that is united to an organic body.

Book VI

Throughout this last Book, Gilbert glories in the Copernican theory, the open, unquestioned, advocacy and endorsement of which according to many seems, after all, to have been the object of the work. He maintains that the magnetic axis of the earth remains invariable; he treats of the daily magnetic revolution of the globes, as against the time-honoured opinion of a *primum mobile*, the fixed stars being at different distances from the earth; of the circular motion of the earth and of its primary magnetic nature, whereby her poles are made different from the poles of the ecliptic, as well as of the precession of the equinoxes and of the obliquity of the zodiac.

According to Humboldt,[1] Gilbert was the first to make use of the words *electric* force, *electric* emanations, *electric* attraction, but, he says, there is not found in "De Magnete" either the abstract expression *electricitas* or the barbarous word *magnetismus* introduced in the seventeenth century. We likewise owe to Gilbert the words *equator*, *magneticum*, *terrella*, *versorium* and *verticitas*, but not the word *pole*, which had before been used by P. Peregrinus and others.

The second edition of "De Magnete" appeared at Stettin in 1628, "embellished with a curious title-page in the form of a monument . . . and a fantastic indication of the earliest European mariner's compass, a floated lodestone, but floating in a bowl on the sea and left behind by the ship sailing away from it." [2]

The third edition was also published at Stettin during 1633. Gilbert left, besides, a posthumous work, "De Mundo Nostro Sublunari Philosophia Nova," Amsterdam, 1651, which latter, says Prof. Robison, consists of an attempt to establish a new system of natural philosophy upon the ruins of the Aristotelian doctrine.[3]

To give here such an analysis as Gilbert's admirable work merits would be impracticable, but the short review of it made by Prof. Robison (at p. 209 of his "System of Mechanical Philosophy," London, 1822) deserves full reproduction, as follows: "In the

[1] "Cosmos," 1860, Vol. II. p. 341, or prior edition, 1849, Vol. II. p. 726.

[2] "Good Words," 1879, with a *facsimile* of the title-page at p. 383.

[3] According to Dr. John Davy, this "De Mundo Nostro," which is but little known, "is a very remarkable book, both in style and matter; and there is a vigour and energy of expression belonging to it very suitable to its originality. Possessed of a more minute and practical knowledge of natural philosophy than Bacon, his opposition to the philosophy of the schools was more searching and particular, and at the same time probably little less efficient" ("Memoirs of the Life of Sir Humphry Davy," London, 1836, Vol. I. p. 311).

introduction, he recounts all the knowledge of the ancients on the subject treated, and their supine inattention to what was so entirely in their hands, and the impossibility of ever adding to the stock of useful knowledge, so long as men imagined themselves to be philosophizing, while they were only repeating a few cant words and the unmeaning phrases of the Aristotelian school. It is curious to mark the almost perfect sameness of Dr. Gilbert's sentiments and language with those of Lord Bacon. They both charge, in a peremptory manner, all those who pretend to inform others, to give over their dialectic labours, which are nothing but ringing changes on a few trite truths, and many unfounded conjectures, and immediately to betake themselves to experiment. He has pursued this method on the subject of magnetism, with wonderful ardour, and with equal genius and success; for Dr. Gilbert was possessed both of great ingenuity, and a mind fitted for general views of things. The work contains a prodigious number and variety of experiments and observations, collected with sagacity from the writings of others, and instituted by himself with considerable expense and labour. It would, indeed, be a miracle if all of Dr. Gilbert's general inferences were just, or all his experiments accurate. It was untrodden ground. But, on the whole, this performance contains more real information than any writing of the age in which he lived, and is scarcely exceeded by any that has appeared since. We may hold it with justice as the first fruits of the Baconian or experimental philosophy." Elsewhere, Prof. Robison remarks: "It is not saying too much of this work to affirm that it contains almost everything we know of magnetism. His unwearied diligence in searching every writing on the subject and in getting information from navigators, and his incessant occupation in experiments, have left very few facts unknown to him. We meet with many things in the writings of posterior inquirers, some of them of high reputation and of the present day, which are published and received as notable discoveries, but are contained in the rich collection of Dr. Gilbert."

The Rev. Wm. Whewell says in his "History of the Inductive Sciences" (Vol. III. p. 49) that in the "De Magnete," a book of only 240 pages, upon which Dr. Gilbert has been engaged for nearly eighteen years, are contained "all the fundamental facts of the science, so fully examined, indeed, that, even at this day, we have little to add to them."

Dr. John Davy remarks ("Memoirs of the Life of Sir Humphry Davy," London, 1836, Vol. I. p. 309): "Gilbert's work is worthy being studied, and I am surprised that an English Edition (translation) of it has never been published." He also alludes to the well-known reproach thrown upon Gilbert's philosophy by Francis

Bacon, who, in his " De Augmentis Scientiarum," observes that " Gilbert has attempted to raise a general system upon the magnet, endeavouring to build a ship out of materials not sufficient to make the rowing-pins of a boat." On the other hand, Digby and Barlowe place Gilbert upon a level with Harvey, Galileo, Gassendi and Descartes (" Nouvelle Biographie Générale," 1858, Vol. VIII. p. 494) while the celebrated historian of the Council of Trent, Fra Paolo Sarpi—who will not be thought an incompetent judge—names Gilbert, with Francis Vieta (the greatest French mathematician of the sixteenth century) as the only original writer among his contemporaries (" Lettere di Fra Paolo," p. 31; Hallam, " Intro. to Lit.," 1859, Vol. II. p. 464).

In Thos. Thomson's " History of the Royal Society," London, 1812, the " De Magnete " is thus alluded to : " Dr. Gilbert's book on magnetism, published in 1600, is one of the finest examples of inductive philosophy that has ever been presented to the world. It is the more remarkable because it preceded the ' Novum Organum ' of Bacon, in which the inductive method of philosophizing was first explained." How far Gilbert was ahead of his time is best proven by the works of those who wrote on magnetism during the first few decades after his death. They contributed in reality nothing to the extension of this branch of physical science. Poggendorff, from whose " Geschichte der Physik," p. 286, this is extracted, as already stated, calls Gilbert " the Galileo of Magnetism." By Dr. Priestley, he was named " the Father of Modern Electricity."

The tribute of Henry Hallam is to the following effect : " The year 1600 was the first in which England produced a remarkable work in physical science; but this was one sufficient to raise a lasting reputation for its author. Gilbert, a physician, in his Latin treatise on the magnet, not only collected all the knowledge which others had possessed on the subject, but became at once the father of experimental philosophy in this island, and, by a singular felicity and acuteness of genius, the founder of theories which have been revived after a lapse of ages, and are almost universally received into the creed of science. Gilbert was one of the earliest Copernicans, at least as to the rotation of the earth, and, with his usual sagacity, inferred, before the invention of the telescope, that there are a multitude of fixed stars beyond the reach of our vision " (" Introduction to the Literature of the Fifteenth, Sixteenth and Seventeenth Centuries," London, 1859, Vol. II. p. 463).

In the " Principal Navigations . . ." Edinburgh, 1889, Vol. XII. p. 10, Richard Hakluyt speaks of " . . . my worshipfull friend M. douctour Gilbert, a gentleman no lesse excellent in the chiefest secrets of the Mathematicks (as that rare iewel lately set forth

by him in Latine doeth euidently declare) then in his oune profession of physicke."

We conclude this account of Gilbert in the quaint words of old Dr. Fuller: "He has (said my informer[1]) the *clearness of Venice Glass* without the *Brittleness* thereof, soon *Ripe* and long *lasting* is his Perfection. He commenced *Doctor* in *Physick*, and was *Physician* to Queen *Elizabeth*, who stamped on him many marks of her Favour, besides an annuall Pension to encourage his studies. He addicted himself to *Chemistry*, attaining to great exactness therein. One saith of him that he was *Stoicall*, but not *Cynicall*, which I understand *Reserved;* but not *Morose*, never married, purposely to be more beneficial to his brethren. Such his *Loyalty* to the Queen that, as if unwilling to survive, he dyed in the same year with her, 1603. His *Stature* was *Tall*, Complexion Chearful, an Happiness not ordinary in so hard a student and so retired a person. He lyeth buried in *Trinity Church* in Colchester under a plain monument."

"*Mahomet's Tombe*, at Mecha, is said strangely to *hang* up, attracted by some invisible *Loadstone*, but the memory of this *Doctor* will never fall to the ground, which his incomparable book 'De Magnete' will *support* to eternity" ("The History of the Worthies of England Endeavoured by Thomas Fuller, D.D.," London, 1662, p. 332—Essex).

In his Epistle to Dr. Walter Charleton, physician in ordinary to King Charles I (Epist. III. p. 15, Vol. XI of the Works of Dryden, London, 1803) the celebrated English poet predicts that:

> "*Gilbert shall live till loadstones cease to draw*
> *Or British fleets the boundless ocean awe.*"

REFERENCES.—"La Grande Encyclopédie," Vol. XVIII. p. 930; "Dictionary of National Biography," London, 1890, Vol. XXI. p. 338; "Bibliographica Britannica," London, 1757, Vol. IV. p. 2202; Larousse, "Dict. Univ.," Vol. VIII. p. 123; "Freeman's Historic Towns" (Colchester), by Rev. E. L. Cutts, 1888, p. 172; "Beauties of England and Wales," by E. W. Brayley and John Britton, 1810, Vol. V. (Colchester) pp. 318–319; Cooper, "Athenæ Cantabrigienses," Cambridge, 1858; Anthony à Wood, "Athenæ Oxonienses," London, 1813, Vol. I; Thomas Wright, "Hist. and Top. of the County of Essex," 1866, Vol. I; "Journal des Savants" for June 1859, Sept. 1870; Wm. Munk, "The Roll of the Royal College of Physicians of London," 1878, Vol. I. p. 77; Humboldt, "Cosmos," 1859–1860, Vol. I. pp. 158–159, note, 177, 179, 182, note; Vol. II. pp. xvii, 279–281, 334–335, 341–342; Vol. V. p. 58 for references to and extracts from Dr. Gilbert's work; Wm. Whewell, "Hist. of the Ind. Sciences," Vol. I. pp. 274–275, 394; Vol. II. pp. 192, 217–220, 224, 225, and "Philosophy of the Ind. Sciences," London, 1840, Vol. II. pp. 374–379; "Mémoires de Physique," Lausanne, 1754, pp. 123, etc.; "U.S. Magnetic Tables and Isogonic Charts for 1902," L. A. Bauer,

[1] Gilbert's near kinsman, Rev. William Gilbert, of Brental Ely, in Suffolk.

pp. 1–77; "Popular Science Monthly," August 1901, pp. 337–350 for "Gilbert of Colchester," by Bro. *Potamian*, also its translation in "Ciel et Terre" for Dec. 1, 1902, pp. 472–480 and for Dec. 16, 1902, p. 489; "New International Encyclopædia," New York, 1903, Vol. VIII. p. 368; "William Gilbert of Colchester," by Conrad Wm. Cooke, London, 1890 (reprinted from "Engineering," 1889); "William Gilbert of Colchester," by Dr. Silvanus P. Thompson, London, 1891; "William Gilbert of Colchester," a translation by P. Fleury Mottelay, New York and London, 1893; "William Gilbert of Colchester," a translation by members of the Gilbert Club, London, 1900, to which is appended a valuable collection of "Notes on the *De Magnete*" of Dr. William Gilbert, by Dr. Silvanus P. Thompson, who therein also gives an interesting bibliography of this great work; "William Gilbert of Colchester," a sketch of his magnetic philosophy by Chas. E. Benham, Colchester, 1902; "Zur bibliographie von W. Gilbert's *De Magnete*," Von. G. Hellmann ("Terrestrial Magnetism and Atmospheric Electricity" for June 1902); "Terr. Magn. and Atm. Elect.," Vol. II. p. 45 for "The Earth a Great Magnet," by J. A. Fleming; "The Earth a Great Magnet," by Prof. Alfred M. Mayer, New York, 1872; Philip Morant, "History and Antiquities of Colchester," London, 1748; Bacon, "Novum Organum," Leyden, 1650, pp. 263–265; Rees' "Encyclopædia," 1819, Vol. XVI. article "Gilbert"; "A Course of Lectures on Natural Philosophy and the Mechanical Arts," by Thos. Young, London, 1807, Vol. I. pp. 686, 747, 756; Vol. II. pp. 111, 324, 436; "Critical Dictionary of Engl. Literature," S. Austin Allibone, Philad., 1888, Vol. I. p. 668; "General Biographical Dictionary," John Gorton, London, 1833, Vol. II, mentioning Wood's "Athen. Ox.," Hutchinson's "Biog.-Med.," and Aikin's "G. Biography"; *Phil. Trans.* for 1667, Vol. II. pp. 527–531, also Baddam's abridgments, London, 1739, Vol. III. p. 129 and London, 1745, Vol. I. p. 97.

A.D. 1601.—Brahé (Tycho—Tygge—Thyghe—Tyge), who has been several times mentioned in this compilation and is referred to by Gilbert ("De Magnete," Book IV. chap. xii. also Book VI. chap. v.), was a distinguished Danish astronomer (*b.* 1546, *d.* 1601), the founder of modern astronomical calculations, whose investigations and records of the positions of the stars and planets made possible the brilliant discoveries of Kepler and Newton. As Humboldt expresses it, the rich abundance of accurate observations furnished by Tycho Brahé, himself the zealous opponent of the Copernican system, laid the foundation for the discovery of those eternal laws of planetary movements which prepared imperishable renown for the name of Kepler, and which, interpreted by Newton, proved to be theoretically and necessarily true, have been now transferred into the bright and glorious domain of thought as *the intellectual recognition of nature* ("Cosmos," 1860, Vol. II. p. 313).

As his very able biographer, Dr. J. L. E. Dreyer, of the Armagh Observatory, remarks in his admirable work (Edinburgh, 1890): "Without Brahé, Kepler never could have found out the secrets of the planetary motions, and, in the words of Delambre, 'Nous ignorerions peut être encore le véritable système du monde.' The most important inheritance which Tycho left to Kepler and to posterity was the vast mass of observations all which, Kepler justly

said, ' deserved to be kept among the royal treasures, as the reform of astronomy could not be accomplished without them . . .' at one breath blowing away the epicycles and other musty appendages which disfigured the Copernican system. . . . Tycho Brahé had given Kepler the place to stand on and Kepler did move the world ! "

Brahé was the first to recognize the variation, *i. e.* the inequality, in the moon's motion. In opposition to the opinion of Sédillot, M. Biot maintains that this fine discovery of Tycho by no means belongs to Abul-Wefa, and that the latter was acquainted not with the " variation " but only with the second part of the " evection " (" Cosmos," 1860, Vol. II. p. 222, wherein are many references to the *Comptes Rendus* and to the " Journal des Savants ").

The biographical division of the " English Cyclopædia," 1866, Vol. I. pp. 898–903, gives a list of Brahé's numerous writings, headed by his earliest publication, " De Nova Stella," 1573, which is so extremely rare that, until 1890, when Dr. Dreyer gave a description of it, not a single historian of astronomy had ever seen it or been able to even give its title correctly (" Journal of Br. Astron. Assoc.," Vol. XII. No. 2, p. 95; Houzeau et Lancaster, Vol. II. p. 598). A detailed account of its contents is given at pp. 44–56 of Dr. Dreyer's 1890 work above alluded to, wherein we are further told of the protection given Brahé by the Landgrave William of Hesse-Cassel, as well as of the consequent aid so liberally extended by King Frederick II. Reference is likewise made to the fact that in December 1584 the King turned to Tycho for help, writing that he was under the impression he had returned a compass made by Tycho, believing there was something wrong with it; that, if this proved to be the case, Tycho was to send back the compass, but, if not, he was to make two new ones similar to the old one (F. R. Friis, " Tyge Brahé," p. 147).

References.—" Life of Tycho Brahé," by Gassendi, containing the " Oratio Funebris," etc., of John Jessenius; Tessier " Eloges des hommes illustres," Vol. IV. p. 383; Blount, " Censura," etc.; " Epistolæ ad Joh. Keplerum," 1718; Riccioli, " Chronicon in Almagesto Novo," Vol. I. p. 46; the biography by Malte-Brun in the " Biog. Univ.," wherein is to be found the list of all of Tycho Brahé's writings; " English Cycl.," Supplement to Biography, p. 376, at Scipione Chiaromonti, for " Anti-Tycho "; " Bulletin de la Société Astronomique de France," Janvier 1903; " Journal des Savants," Juin 1864; Humboldt, " Cosmos," 1860, Vol. III. pp. 158, 160, 162; " Nature " of Dec. 27, 1900, p. 206, and " Nature," Vol. LXV. pp. 5–9, 104–106, 181, as well as the " Bulletin Astronomique," Paris, Avril 1902, pp. 163–166, for account of the celebrations of the Tercentenary of Tycho-Brahé's death, held at Prague and elsewhere, on Oct. 24, 1901, with illustrations of his observatory, etc. etc.; " Geschichte der Mathem. von Abraham G. Kästner," Vol. II. pp. 376, etc., 613, etc.; R. A. Proctor, " Old and New Astronomy," 1892 *passim;* " Biog. Génér.," 1890, Vol. XLV. pp. 750,

755; "La Grande Encycl.," Vol. VII. pp. 962–963; Larousse, "Dict. Univ.," Vol. XV. pp. 613–614; "Encycl. Brit.," Edin., 1876, Vol. IV. p. 200.

Consult likewise for Abul Wefa: "Le Journal des Savants," for Nov. 1841, Sept. 1843, Mar. 1845 and Oct. 1871; Houzeau et Lancaster, "Bibliog. Gén.," 1887, Vol. I. pp. 598–600, and Vol. II. pp. 92–93; "Bull. de la Soc. Acad. de Laon," Janvier 1903, pp. 40–48; Leopold Von Ranke, "History of England," Vol. I. p. 367 and notes; Wm. Whewell, "Phil. of the Ind. Sc.," London, 1840, Vol. II. pp. 386–388; Harold Höffding, "A Hist. of Mod. Phil.," translated by B. E. Mayer, London, 1900, Vol. I. p. 428.

A.D. 1602.—Blundeville (Thomas) publishes at London, "The Theoriques of the Seuen Planets," etc., which, as the lengthy title goes to show, indicates "the making, description and vse of two ingenious and necessarie instruments for sea men to find out thereby the latitude of any place upon the sea or land, in the darkest night, that is, without the helpe of sunne, moone or starre; first invented by M. Dr. Gilbert, a most excellent philosopher, and one of the ordinarie physicians to Her Majestie."

He had previously published, in 1589, "A briefe description of universal mappes and cardes and of their use; and also the use of Ptolemy his Tables," which was followed, during 1594, by his well-known work on navigation. From the rare sixth edition of the latter (London, 1622) the curious title page is worth reproducing as follows: "M. Blundeville, His Exercises, contayning eight treatises, the titles whereof are set down in the next printed page: which treatises are very necessary to be read and learned of all Young Gentlemen that haue not beene exercised in such Disciplines and yet are desirous to haue knowledge as well in Cosmographie, Astronomie and Geographie, as also in the art of navigation, in which art it is impossible, to profit without the helpe of these or such like Instructions. To the furtherance of which Art of Navigation the sayd Master Blundeville especially wrote the said Treatises and of meere good will doth dedicate the same to all Young Gentlemen of this Realme." The contents of this curious work treat of Arithmetic, Cosmography, Terrestrial and Celestial Globes, Peter Plancius, his Universal Map, Mr. Blagrau, his Astrolabe, The First Principles of Navigation, etc. etc.

The Mr. Blagrau here mentioned is John Blagrave, eminent English mathematician, author of "The Mathematical Jewel," as well as of "The making and use of the familiar staffe," of "The Art of Dialling," and of "Astrolabium Uranicum Generale, a necessary and pleasunt solace and recreation for Navigators in their long journeying, containing the use of an instrument or astrolabe." From the last named, it appears that Blagrave was a convert to the heliocentric theory of Copernicus ("New Gen.

Biog. Dict.," by Rev. H. J. Rose, London, 1850, Vol. IV. p. 277). The invention of the dipping needle by Mr. Blagrave was before the discovery of the change of the needle's variation by Mr. Gellibrand ("Philos. Britan.," Benj. Martin, London, 1771, Vol. I. p. 46).

REFERENCES.—"Gen. Biogr. Dict." (Gorton), London, 1833, Vol. I; Hutton's abridgments of the *Phil. Trans.*, London, 1739, Vol. IV. p. 103; "Dict. of Nat. Biog.," Leslie Stephen, London, 1886, Vol. V. pp. 157 and 271–272; "Gen. Biog. Dict.," Alex. Chalmers, London, 1812, Vol. V. pp. 370–371; "Biog. Univ.," Paris, 1843, Vol. IV. p. 397; "Nouv. Biog. Générale" (Hœfer), Paris, 1853, pp. 170–171; Baddam's abridgments of the *Phil. Trans.*, London, 1739, Vol. IV. p. 103; "Ames' Typog. Antiq." (Herbert), pp. 693, 694, 697–701; Bloomfield's "Norfolk," Vol. LXIV. pp. 68–70; Cooper's "Athenæ Cantab."; Davy's "Suffolk Coll.," Vol. LXXXIX. p. 215; Hazlitt, "Coll. and Notes," 1876, also the second series.

A.D. 1609.—Kepler (Johann), who succeeded Tycho Brahé in 1601 as astronomer to the German Emperor Rudolph II, is the author of a treatise "On the Magnet," which was followed, during 1609, by his greatest work, the "Astronomia Nova." The latter was deemed by Lalande of such importance that he considered it the duty of every astronomer to read it from beginning to end at least once in his lifetime.

The "Astronomia" contains the extraordinary book "on the motion of Mars," and is said to hold the intermediate place, besides being the connecting link between the discoveries of Copernicus and those of Newton. Kepler's doctrine is thus enunciated by Dr. Whewell ("Physical Astronomy," Chap. I): "A certain Force or Virtue resides in the sun by which all bodies within his influence are carried around him. He illustrates ('De Stella Martis,' Chap. XXXIV. p. 3) the nature of this Virtue in various ways, comparing it to Light and to the Magnetic Power, which it resembles in the circumstances of operating at a distance, and also in exercising a feebler influence as the distance becomes greater." In the Table of Contents of the work on the planet Mars, the purport of the chapter to which allusion has been made is stated as follows: "A Physical speculation, in which it is demonstrated that the vehicle of that virtue which urges the planets, circulates through the spaces of the universe after the manner of a river or whirlpool (vortex), moving quicker than the planets." It will doubtless be found by any one who reads Kepler's phrases concerning the *moving force*—the *magnetic nature*—the *immaterial virtue* of the sun, that they convey no distinct conception, except so far as they are interpreted by the expressions here quoted: "A vortex of fluid constantly whirling around the sun, kept in this whirling motion by the rotation of the sun himself and carrying the planets around the sun by its revolution,

as a whirlpool carries straws, could be readily understood; and though it appears to have been held by Kepler that this current and vortex was immaterial, he ascribes to it the power of overcoming the inertia of bodies, and of putting them and keeping them in motion, the only material properties with which he had anything to do. Kepler's physical reasonings, therefore amount, in fact, to the doctrine of vortices around the central bodies and are occasionally so stated by himself; though by asserting these vortices to be 'an immaterial species,' and by the fickleness and variety of his phraseology on the subject, he leaves his theory in some confusion; a proceeding, indeed, which both his want of sound mechanical conceptions and his busy and inventive fancy might have led us to expect. Nor, we may venture to say, was it easy for any one at Kepler's time to devise a more plausible theory than the theory of vortices might have been made. It was only with the formation and progress of the science of mechanics that this theory became untenable."

References.—"Kepler, sa vie et ses ouvrages," in the "Journal des Savants" for June, July and August 1847; Kepler's manuscripts, "Phil. Trans.," Vol. XI. p. 27; Wm. Whewell, "Phil. of the Ind. Sc.," London, 1840, Vol. II. pp. 383–386; "Epistolæ ad J. Keplerum," published by M. G. Hansch in 1718; Houzeau et Lancaster, "Bibliogr. Générale," 1887, Vol. I. part i. pp. 612–614, detailing the contents of Kepler's "Opera Omnia," also Vol. I. part ii. pp. 1315–1316, 1330–1331, 1383, and Vol. II. pp. 175–176, 456–462 and 1581; Robert Small, "An Account of the Astronomical Discoveries of Kepler," London, 1804; Humboldt, "Cosmos," 1860, Vol. II. p. 710, notes, for Laplace, Chasles and Brewster on the writings and theories of Kepler; "Jour. des Savants" for June, July and August 1847; "Geschichte der Mathem.," Vol. III. p. 318, and Vol. IV. pp. 216, 311; Dr. Geo. Miller, "Hist. Phil. Ill.," London, 1849, Vol. III. notes at pp. 134–135; Fourth Dissert. of "Encycl. Brit."; Whewell, "Hist. of the Ind. Sc.," 1859, Vol. I. pp. 291–311, 320, 386, 387, 415, 462, 532–534, and Vol. II. pp. 55, 56.

It will be well to look at the last-named work of Dr. Whewell for references to Jeremiah Horrox—Horrockes—(1619–1641), the celebrated young English scientist, who wrote in defence of the Copernican opinion in his "Keplerian Astronomy defended and promoted" ("Hist. of the Ind. Sc.," Vol. I. Book V. chap. iii. p. 276, and Chap. V. p. 303), as well as for references to Giovanni Alfonso Borelli (1608–1679). Borelli, who has by many been erroneously called a pupil of Galileo, was a distinguished Italian physicist and astronomer, born at Naples in 1608, who founded what has been called the iatromathematical school, which, under the protection of Leopold of Tuscany, became known as the Accademia del Cimento. Whewell speaks of him in Vol. I. at Book VI. chap. ii. p. 323, at Book VII. chap i. pp. 387, 393, 394, and at Chap. II. pp. 303, 395, 405, 406. Horrox is mentioned, more particularly, by Houzeau et

Lancaster ("Bibliog. Générale," Vol. II. p. 167), also at pp. 12 and 220, Vol. II of Hutton's abridgments of the *Phil. Trans.*; while full accounts of the many important works of Borelli are to be found in "Biogr. Générale," Vol. VI. pp. 700–701; Ninth "Britannica," Vol. IV. p. 53; Larousse, "Dict. Univ.," Vol. II. p. 1003; "Chambers' Encycl.," 1888, Vol. II. p. 328; "La Grande Encycl.," Vol. VII. p. 405; Nicéron, "Mémoires," Vol. VIII. p. 257; Vigneul-Marville, "Mélanges," Vol. II. p. 122; Sachs, "Onomasticon Literarium," V. 40; Hagen, "Memoriæ Philosophorum," Frankfort, 1710.

A.D. 1613.—Ridley (Marke), "Doctor in physicke and philosophie, latly physition to the Emperour of Russia and one of ye eight principals or elects of the College of Physitions in London," is the author of a small quarto entitled "A Short Treatise of Magnetical Bodies and Motions," published in London, 1613. Of this treatise, Libri says that the author, in his preface, deals tolerantly with the many and varied theories concerning magnetic bodies, instancing many of the most notable from those of Pliny and Nicander to those of Robert Norman. He is particularly emphatic concerning the production of perpetual motion by means of the loadstone, finding it "by the experience of many ingenious practices . . . impossible to be done."

From the notice given him in "Dict. of Nat. Biog.," 1896, Vol. XLVIII. pp. 285–286, we learn that in the above-named work, he claims acquaintance with William Gilbert, whom he commends as the greatest discoverer in magnetical science, and that after giving twenty-four chapters on the properties and description of the magnet, he discusses the variation of the compass and methods of estimating it in eight chapters, the inclinatory needle in eight others, concluding with a chapter on finding the longitude and one "of the matter of the magnetical globe of the earth by the needle."

In 1617, he published "Animadversions on a late work entitled Magnetical Advertisement; or, Observations on the Nature and Properties of the Loadstone."

References.—A. Watt, "Bibliotheca Britannica," Vol. II. p. 804, at p. 75*g* Vol. I. of which (article, "Wm. Barlowe") is "A briefe discovery of the idle animadversions of Marke Ridley, M.D.," upon a treatise entitled "Magneticall Advertisements," London, 1618. Consult also "The Lancet" of August 7, 1897, p. 349; Munk's "College of Phys.," Vol. I. p. 106; Ridlon's "Ancient Ryedales," p. 425.

A.D. 1616.—Schouten (Guillaume Cornelissen—Willem Cornelisz), Dutch navigator, indicates points lying in the midst of the Pacific and south-east of the Marquesas Islands in which the

variation is null. Humboldt alludes to this ("Cosmos," 1859, Vol. I. p. 182, and Vol. V. p. 59) and says, "Even now there lies in this region a singular, closed system of isogonic lines, in which every group of the internal concentric curves indicates a smaller amount of variation."

For Schouten, consult "Relation," published by Aris Classen, Amst., 1617; Larousse, "Dict. Univ.," Vol. XIV. p. 375.

Under this same date, A.D. 1616, Chas. Pickering tells us that Wm. Baffin (Churchill Coll. and Anders. II. 268) continued North to "seventy-eight degrees," as far as a Sound called by him "Thomas Smith's," where the compass varied "fifty-six degrees to the westward," making the true North bear N.E. by E. The northern expanse of water received the name of "Baffin's Bay" ("Chron. Hist. of Plants," Boston, 1879, p. 933).

A.D. 1617.—Strada (Famianus), an Italian author and Jesuit priest, publishes his curious "Prolusiones Academicæ," wherein he describes (lib. ii. prol. 6) a contrivance consisting of two magnetic needles attached to two dials each bearing a circle of letters so arranged that when one needle is made to point to any letter on one dial, the other needle points to the same letter upon the other dial.

The description is best given in his own words taken from the original Latin (Stradæ, "Prol. Acad.," Oxoniæ, 1662, "Magnes cur ferrum aut aurum trahat," pp. 326–335): ". . . If you wish your distant friend, to whom no letter can come, to learn something, take a disc or dial, and write round the edge of it the letters of the alphabet in the order in which children learn them, and, in the centre, place horizontally a rod, which has touched a magnet, so that it may move and indicate whatever letter you wish. Then a similar dial being in the possession of your friend, if you desire privately to speak to the friend whom some share of the earth holds far from you, lay your hand on the globe, and turn the movable iron as you see disposed along the margin of all the letters which are required for the words. Hither and thither turn the style and touch the letters, now this one, and now that. . . . Wonderful to relate, the far-distant friend sees the voluble iron tremble without the touch of any person, and run now hither, now thither; conscious he bends over it and marks the teaching of the rod. When he sees the rod stand still, he, in his turn, if he thinks there is anything to be answered, in like manner, by touching the various letters, writes it back to his friend. . . ."

REFERENCES.—"The Student; or, Oxford and Cambridge Misc.," 1750, Vol. I. p. 354; Abbé Moigno's "Traité de Tel. Elec.," p. 58;

Addison (Joseph), "Spectator" for December 6, 1711, No. 241 (p. 273, Vol. II. London ed., 1854); the "Guardian" for 1713, No. 119, and "Nature," Vol. XVI. pp. 268, 269. Also "Academy and Literature" of January 7, 1905. Zachary Grey, in 1744 edition of Butler's "Hudibras," quotes from the "Guardian."

A.D. 1620.—Bacon (Sir Francis), by many considered the greatest of English philosophers and philosophical writers (1561–1626), who was knighted in 1603, became Earl of Verulam in 1618 and Viscount St. Albans in 1620; produces the masterpiece of his genius, the "Novum Organum," after having twelve times copied and revised it. The last-named work, observes Macaulay, "takes in at once all the domains of science—all the past, the present and the future, all the errors of two thousand years, all the encouraging signs of the passing times, all the bright hopes of the coming age." Prof. Playfair says of it that "the power and compass of the mind which could form such a plan beforehand, and trace not merely the outline but many of the most minute ramifications of sciences which did not yet exist, must be an object of admiration to all succeeding ages."

It was Sir John Herschel who remarked that "previous to the publication of the 'Novum Organum' natural philosophy, in any legitimate and extensive sense of the word, could hardly be said to exist." In the address presented in 1623 by the University of Oxford to Sir Francis Bacon, he is represented "as a mighty Hercules who had by his own hand greatly advanced those pillars in the learned world which by the rest of the world were supposed immovable."

Treating of the electric fluid, Bacon has given ("Physiological Remains," London, 1648) a detailed list of attractive and non-attractive bodies and the results of his very extensive experiments and observations in physical science generally, as well as of the investigations contained in Dr. Gilbert's work. To the latter, however, many allusions had already been made in Bacon's "The Advancement of Learning," published during 1605, two years before he was made Solicitor-General.

The most satisfactory analyzation of Bacon's researches is to be found in the attractive edition of his complete works published by Spedding, Ellis and Heath, fifteen volumes, Boston, 1863. Therein will be seen the following references to the magnet and magnetic virtue :

Vol. I. p. 435 (note). In Gilbert's philosophy, the earth's magnetic action is not distinguished from gravity (De Mundo, II. c. 3). That the magnetic action of the earth or of a magnet

is confined to a definite orb, appears from a variety of passages (see "De Magnete," II. c. 7, and the definitions prefixed to this work). Gilbert distinguished between the "Orb of Virtue," which includes the whole space through which any magnetic action extends, and the "Orb of Coition," which is *totum illud spatium per quod minimum magneticum per magnetem movetur.* He asserts that the orb of the magnetic virtue extends to the moon and ascribes the moon's inequalities to the effects it produces ("De Mundo," II. c. 19).

Vol. VIII. Aphorisms. "If, before the discovery of the magnet, any one had said that a certain instrument had been invented by means of which the quarters and points of the heavens could be taken and distinguished with exactness . . . it would have been judged altogether incredible . . ." (pp. 141–142). "The 'Clandestine Instances'—which I also call 'Instances of the Twilight' [the attraction or coming together of bodies]—and which are pretty nearly the opposite of 'Striking Instances. . . .' The most remarkable 'Striking Instance' is the magnet . . . a 'Clandestine Instance' is a magnet armed with iron; or, rather, the iron is an armed magnet . . ." (pp. 224–226). "The polarity of the iron needle when touched with the magnet" (p. 261). "The magnetic or attractive virtue admits of media without distinction, nor is the virtue impeded in any kind of a medium" (p. 269). "There is no medium known by the interposition of which the operation of the magnet, in drawing iron, is entirely prevented" (pp. 285–286). "A piece of a magnet does not draw so much iron as the whole magnet" (p. 301). "As for the help derived from the virtue of a cognate body, it is well seen in an armed magnet, which excites in iron the virtue of detaining iron by similarity of substance; the torpor of the iron being cast off by the virtue of the magnet" (p. 311). "There are four virtues or operations in the magnet . . . the first is the attraction of magnet to magnet, or of iron to magnet, or of magnetised iron to iron; the second is its polarity, and at the same time its declination; the third, its power of penetrating through gold, glass, stone, everything; the fourth, its power of communicating its virtue from stone to iron, and from iron to iron, without communication of substance" (p. 313). "But the flight of iron from one pole of the magnet is well observed by Gilbert to be not a flight strictly speaking, but a conformity and meeting in a more convenient situation" (p. 315). "The magnet endues iron with a new disposition of its parts and a conformable motion, but loses nothing of its own virtue" (p. 318).

Vol. IX. In the fifth book of "De Augmentis Scientiarum," these questions are asked: (1) A magnet attracts a solid piece of iron; will a piece of a magnet dipped in a dissolution of iron attract the iron itself and so get a coating of iron? (2) Again, the magnetic needle turns to the pole; does it, in so doing, follow the same course as the heavenly bodies? (3) And, if one should turn the needle the wrong way, that is, point it to the South and hold it there for a while, and then let it go; would it, in returning to the North, go round by the West rather than by the East? (pp. 75–76).

Vol. X. This contains, at pp. 269–272, the "Inquiry respecting the Magnet," of which the original paper is to be found in Vol. IV. pp. 121–125. In Dr. Rawley's list of works composed by Bacon, during the last five years of his life, this "Inquisitio de Magnete," first published in 1658, stands last but two. At p. 335 of this same Vol. X will be found an extract from "De fluxu et reflexu maris" ("The ebb and flow of the sea") relative to the inquiry as to whether the earth itself is a magnet, as was asserted by Gilbert.

Besides the "Clandestine Instances" or "Instances of the Twilight" alluded to above, mention could have been made more particularly of Bacon's observations (in s. 3 of the "Nov. Organ.") under the direct headings of "Instantiæ Citantes . . . Supplementi . . . Radii . . . Magicæ," as well as of "Motus Magneticus . . . Excitationis . . . Fugæ," etc., which are fully explained at ss. 190–200 of Sir John Herschel's "Discourse on the study of Natural Philosophy."

They have been analyzed as follows:

Instantiæ Citantes, to which may be reduced the "discovery of a moving magnetic fluid, or an action circular and perpendicular to the electrical current, yet connected with it."

Instantiæ Supplementi, such as the magnet which attracts iron through many substances that may be interposed. Perhaps, says he, "some medium may be found to deaden this virtue more than any other medium; such an instance of *substitution,* would be in the way of degree, or *approximation*"; that is, it would approach toward destroying the magnetic virtue. Iron possesses, perhaps, this quality in a more marked manner than any other substance.

Instantiæ Radii, leading to the suggestion that there may exist some kind of "magnetic virtue which operates by consent,

between the globe of the earth and heavenly bodies; or between the globe of the moon and the waters of the sea; or between the starry heavens and the planets, by which they may be drawn to their apogees," or greatest distances from the earth.

Instantiæ Magicæ, such as the loadstone animating a number of needles without loss of its own magnetism.

Motus Magneticus, such as the attraction of the heavenly bodies, from an idea, perhaps, that it might be due to a species of magnetism.

Motus Excitationis, such as the new property which is given to iron by the magnet without any loss of power by the latter.

Motus Fugæ, such as "the repulsion of electrified pith balls; also of the similar poles of two magnets. In the latter case, all the force of a strong man has proved insufficient to make the two north poles touch each other."

The last-named work of Sir John Herschel is alluded to, under the heading of "Prerogative Instances" ("Prærogativæ Instantiarum") by Thomas Fowler, who calls attention to the fact that among the contemporaries of Francis Bacon by whom the Copernican theory was rejected are: Tycho Brahé (who, however—having died in 1601—did not live to become acquainted with the discoveries of Galileo); Vieta, the greatest mathematician of the sixteenth century (who died as early as 1603); Christopher Clavius (who was employed by Gregory XIII to reform the Calendar and was called the Euclid of his age); and possibly, from his silence, the famous mechanician Stevinus (Delambre, "Histoire de l'Astronomie Moderne").

References.—The works of Sir Francis Bacon, Lord Chancellor of England, by Basil Montagu, 16 vols., London, 1825–1834, and the review thereof made by Thomas Babington Macaulay ("Essays," 1855, Vol. II. pp. 142–254 ("Edinburgh Review," July 1837); Dr. W. Windelbrand, "History of Philosophy, New York, 1893, translated by Jas. H. Tufts, pp. 380–388; Dr. Friedrich Ueberweg, "History of Philosophy," translated by Geo. S. Morris, New York, 1885, Vol. II. pp. 33–38; Leopold Von Ranke, "History of England," Vol. I. pp. 455–459, Vol. III. p. 383; William Whewell, "The Philosophy of the Inductive Sciences," London 1840, Vol. II. pp. 388–413; "Critical Dictionary of English Literature," S. Austin Allibone, Philad. 1888, Vol. I. pp. 89–96; "Catalogue Général des livres imprimés de la Bibliot. Nation.," Paris, 1901, Vol. VI. pp. 236–253; Chas. Wells Moulton, "Library of Literary Criticism," Vol. I. pp. 638–669; "The Philosophical Works of Francis Bacon," by John M. Robertson, New York, 1905; "The Grammar of Science," by Karl Pearson, London, 1900, pp. 506–508; "Encycl. Britann.," Edinburgh, 1842, seventh edition, Vol. I. as per Index pages 16–17 and at "Dissertation First," pp. 32–40· "Essai Theorique . . . des connaissances humaines," par G. Tiberghien, Bruxelles, 1844, Vol. II. pp. 409–419; Geo Miller, "History Philosophically Illustrated," London, 1849, Vol. II. p. 430; "Francis Bacon," by B. G. Lovejoy, London, 1888; "His Life and Character," pp. 1–188,

and "His Essays and Extracts," pp. 19–277; "Francis Bacon," by Kuno Fisher, London, 1857; "Encycl. Brit." ninth edition, Vol. III. pp. 200–218; Bacon's "Novum Organum," by Thomas Fowler, New York, 1881, and Oxford, 1889; "Histoire des Sciences," par F. L. M. Maupied, Paris, 1847, Vol. II. pp. 252–281, for "Enumeration Méthodique—Eléments—Analyse—des ouvrages de Francis Bacon"; "Library of Useful Knowledge," for account of Lord Bacon's "Novum Organum"; "Epitome of Electricity and Galvanism," Philad., 1809, pp. xvi, 105; Whewell, "History of the Inductive Sciences," Vol. I. pp. 339, 385, 494, 530; Van Swinden, "Recueil de Mémoires . . ." La Haye, 1784, Vol. II. pp. 355, 364, 369–370; and, for an exhaustive biographical account of Francis Bacon, consult the "English Cyclopædia," Vol. I. pp. 470–476. It is stated by C. R. Weld in his "History," Vol. I. p. 64, that the establishment of the Royal Society was much accelerated by the writings of Lord Bacon (Buchmeri, "Acad. Nat. curi. Hist.").

A.D. 1620–1655.—Bergerac (Savinien Cyrano de), a very witty French writer, is the author of a fragment on physics, as well as of a curious philosophical romance, "Histoire comique des états et empires de la lune," a translation from which latter is here given, as in a measure suggesting the phonograph: "On opening the box, I found a number of metallic springs and a quantity of machinery resembling the interior of our clocks. It was, in truth, to me a book, indeed, a miraculous book, for it had neither leaves nor characters, and to read it, one had no need of eyes, the ears alone answering the purpose. It was only necessary to start the little machine, whence would soon come all the distinct and different sounds common to the human voice."

Another translation reads as follows: "On opening the box I found inside a concern of metal, something like one of our watches, full of curious little springs and minute machinery. It was really a book, but a wonderful book that has no leaves or letters; a book, for the understanding of which the eyes are of no use—only the ears are necessary. When any one wishes to read, he winds up the machine with its great number of nerves of all kinds, and turns the pointer to the chapter he wishes to hear, when there come out, as if from the mouth of a man or of an instrument of music, the distinct and various sounds which serve the Great Lunarians as the expression of language."

As has been said by one of his biographers, "amid the extravagance of some of his works, Bergerac nevertheless exhibited a pretty good acquaintance with the philosophy of Descartes."

References.—Article "Aeronautics" in the "Encycl. Brit.," 1853, Vol. II. p. 168; Larousse, "Dict.," Vol. V. p. 730.

A.D. 1621.—Helmont (Jean Baptiste van), famous Belgian scientist, publishes in Paris his "De Magnetica," etc. (on the magnetic cure of wounds). His theories on magnetism greatly

resemble those of Paracelsus, but in his treatment of them he shows himself much superior to the Swiss alchemist, whom Dr. Hœfer says he took as his model. "Magnetism," Van Helmont observes, "is an unknown property of a heavenly nature, very much resembling the stars, and not at all impeded by any boundaries of space or time. . . . Every created being possesses his own celestial power and is closely allied with heaven . . . the spirit is everywhere diffused; and the spirit is the medium of magnetism . . . it is not the spirits of heaven and of hell which are masters over physical nature, but the soul and spirit of man which are concealed in him as the fire is concealed in the flint."

The above-named work of Van Helmont was "translated, illustrated and ampliated," in 1650 by Dr. Walter Charleton, physician in ordinary to King Charles I, under the name of "A Ternary of Paradoxes." From its interesting contents, we make the following extracts :

Page 10. "A loadstone placed upon a small trencher of wood, floating on water, does instantly in one determinate point *australize*, and in the other *septentrionate* . . . all which various and admirable effects of the loadstone, thou maiest, if thy judgement relish them, finde made good by multiplyed observations, by William Gilbert, not many yeers past, a physician in London, in his book, 'De Magnete': of which subject no man ever writ more judiciously or experimentally: and by whose industry the variation of the compasse may be restored . . ."

Page 12. "There is a book imprinted at Franekera, in the year 1611, by Vldericus Dominicus Balck, of the *Lamp of Life*. In which you shall finde, out of Paracelsus, the true magneticall cure of most diseases, as of the Dropsie, Gout, Jaundice, etc."

Page 15. "Doth not the needle of the Mariner's Compasse, through a firme glasse, closely sealed up with melted soder (in which there can be no pore or crany discovered) steer it self to the Artick pole? . . . wherefore the same numericall *accident* streaming in one continued *radius* from the loadstone into the *aer*, passes through the glasse, and perhaps goes as farre as to touch the pole it self . . ."

Page 38. "Wherefore the loadstone owes its polarity to a natural inhærent faculty, flowing from its owne seminall entity, and not to any forreigne alliciency, or attractive influx transmitted from the north star. But that otherwise the loadstone may, by its own instinct, be elevated towards the Zenith, we have upon ocular demonstration found it true, by a certain instrument

invented by Guilielme Guilbert (the glory of which excellent invention Ludovicus Fonseca hath lately endeavoured to ravish) . . . which by the spontaneous elevation of the loadstone in a brasse ring suspended by a thread or small wier, shews not only the latitude but also the altitude of the pole, in all places of the earth."

Page 39. " . . . the loadstone is endued with a *domestick pilot, a directive faculty,* which guides it to some determinate place, but is not at all attracted by the pole."

Page 40. " The loadstone onely by the affriction of *Garlick,* amits its *verticity,* and neglects the pole, conserving to it self, in the meane time, its peculiar forme, materiall constitution, and all other dependent proprieties. The reason, because *Garlick* is the loadstone's proper Opium, and by it that spirituall sensation in the magnet is consopited and layd asleep. . . . Verily, that alliciency of the pole must be extreame weake and of inconsiderable energy, which passing through so many and so immense orbes of heaven, and striking through great and firme buildings, and thick walls, cannot yet be of power sufficient to pierce the thin juice of Garlick or the fume of Mercury . . ."

Page 42. " There is therefore inhærent in the magnet an *influentiall virtue,* which, being not obliged to the propinquinty or comtiguous admotion of its object, is after the nobler names of coelestiall influences, freely and without interruption or languor transmitted so farre as to the pole it self : since there is a spontaneous *eradiation,* or emission of atomicall *radii* from the body of the magnet to the pole."

Page 74. " That the magnetisme of the loadstone and other inanimate creatures is performed by a certaine naturall sensation, the immediate anthrix of all sympathy, is a truth unquestionable."

Page 75. " For by one phansy it is directed to iron, and by another to the pole . . . the phansy of *amber* delights to allect strawes, chaffe, and other festucous bodies ; by an attraction, we confesse, observe obscure and weake enough, yet sufficiently manifest and strong to attest an *Electricity* or attractive signature . . ."

REFERENCES.—" Dict. of Nat. Biog.," Vol. X. pp. 116–119, containing a full list of Charleton's works ; Thomson, " Hist. of the Roy. Soc.," 1812, p. 3 ; Munk, " Coll. of Phys.," 1878, Vol. I. p. 390 ; " Journal des Savants " for February and March 1850, June 1851 ; Mme. Blavatsky, " Isis Unveiled," Vol. I. p. 170 ; Eloy, " Dict. Hist. de la Médecine," Vol. II. pp. 478–482 ; " Dict. Hist. de la Médecine," par. J. E. Dezeimers, Paris, 1839, Vol. III. pp. 97–104 ; " Ency. Brit.," ninth edition, Vol. XI. p. 638 ; " History and Heroes of the Art of Medicine," by J. Rutherfurd Russell, London, 1861, pp. 197–204 ; Larousse, " Dict. Univ.," Vol. IX.

p. 158; Van Swinden, "Recueil," La Haye, 1784, Vol. II. pp. 351–352, 361–363; Joseph Ennemoser, "The History of Magic," London, 1854, Vol. II. pp. 242–253.

A.D. 1623.—Hervart—Heroart—Herwart—Hörwarth (Joannes Fridericus), son of Johann Georg Hervart ab Hohenburg, the well-known scientist (1554–1622), who during forty-five years occupied the post of Bavarian Chancellor under three reigning princes—completes his father's work entitled "*Admiranda ethnicæ theologiæ . . .*" which, Larousse says ("Dictionnaire Universel," Vol. IX. p. 250), was published at Munich, 1624, and in which he demonstrates that the earlier Egyptian divinities were natural phenomena personified and adored under symbolic names. Michaud, who reiterates this ("Biographie Universelle," Vol. XIX. p. 364), speaks of the edition which appeared at Munich in 1626, and he also states that, at the end of the latter, will be found "*Exacta temporum . . . chronologiæ vulgaris errores,*" which is the continuation of the "*Chronologia Nova,*" left unfinished by the Bavarian Chancellor. This is, in fact, so mentioned in the only copy possessed by the British Museum, which was published by J. F. Hervart ab Hohenburg at Ingolstadii, 1623, and of which the title reads: "*Admiranda Ethnicæ Theologiæ Mysteria propalata. Ubi lapidem magnetem antiquissimis passim nationibus pro Deo-deo-cultum: et artem qua navigationes magneticæ per universum orbem instituerentur. . . .*"

Libri's "Catalogue," 1861, Part I. p. 405, No. 3703, has the following entry: "*Admiranda Ethnicæ . . . ubi Lapidem Magnetem antiquissimis Nationibus pro Deo cultum commonstratur . . .*" Ingolstadii, 1623. The work itself endeavours to prove that the loadstone's properties were well known to the ancients.

The "General Biographical Dictionary" of Alexander Chalmers, London, 1814, Vol. XVII. p. 426, makes following entry: "Herwart (or Hervart) John George, Chancellor of Bavaria at the beginning of the seventeenth century, published some works wherein his learning was more displayed than his judgment, in supporting the most extravagant systems. Two of his works are: '*Chronologia nova et vera,*' in two parts, 1622 and 1626, and '*Admiranda Ethnicæ Theologicæ Mysteria propalata, de antiquissima veterum nationum superstitione, qua lapis Magnes pro Deo habitus colebatur,*' Monach, 1626, quarto. It was here asserted that the ancient Egyptians worshipped the magnet," etc. (see Deveria, under B.C. 321).

REFERENCES.—Allusions to Hervart, made at p. 546, Vol. XXIV. of Dr. Hœfer's 1861 "Nouvelle Biographie Générale," or at p. 546, Vol. XXVIII of the 1858 edition, and also at p. 163, Vol. II of the "Bibliographie Générale de l'Astronomie," by Houzeau et Lancaster,

Bruxelles, 1882. Likewise Chr. G. Jöcher, "Compendiöses Gelehrten Lexicon," Leipzig, 1787, Vol. II. p. 1969, and "A New General Biogr. Dict.," London, 1850, Vol. VIII. p. 304.

A.D. 1624.—Gunter (Edmund), professor of astronomy at Gresham College, publishes his work "Of the Sector, Cross-Staff, and other Instruments," at Chap. V of the second book of which he gives the result of the eight observations he made on the variation of the variation "in various parts of the ground" at Limehouse on the 13th of June, 1622. His observations of the declination, as given by Prof. Gellibrand, are detailed at Chap. I of Walker's "Ter. and Cos. Mag.," Cambridge, 1866.

References.—De La Rive, "Electricity," etc., Vol. I. p. 165; Poggendorff, "Geschichte der Physik," Leipzig, 1879, p. 275.

A.D. 1625.—Carpenter (Nathaniel), Dean of Ireland, well-known mathematician, publishes at Oxford, "Geography delineated forth in two bookes, containing the sphæricall and topicall parts thereof," wherein he thus alludes to Dr. Gilbert's "De Magnete": "Magneticall proprieties, I find in ancient writers, as little knowne as their causes; and if any matter herein were broached, it was merely conjectural, and depending on no certain demonstration; neither had we any certain or satisfactory knowledge of the thing vntill such time as it pleased God to raise vp one of our countrymen, D. Gilbert, who, to his euerlasting praise, hath trodden out a new path to Philosophie, and on the Loadstone, erected a large Trophie to commend him to posterity. This famous Doctor being as pregnant in witty apprehension as diligent in curious search of naturall causes, after many experiments and long enquiry, found the causes of most magneticall motions and proprieties hid in the magneticall *temper* and constitution of the Earth, and that the earth it selfe was a meere magneticall body challenging all those proprieties, and more than haue expressed themselves in the Loadstone; which opinion of his was no sooner broached than it was embraced, and wel-commed by many prime wits as well English as Forraine. Insomuch that it hath of late taken large root and gotten much ground of our vulgar Philosophie."

References.—"Nature," September 26, 1901; "Dict. of Nat. Biogr.," Vol. IX. pp. 161–162; Larousse, "Dict.," Vol. IV. p. 438; Prince's "Worthies" (1810), pp. 173–175, 603.

A.D. 1625.—Naudé (Gabriel), a celebrated French savant and one of the most learned of his day, also physician to King Louis XIII, and an intimate friend of Gassendi, is the author of "Apologie pour tous," etc. ("Apology for great men falsely accused of magic"), of which other editions appeared in 1652, 1669 and 1712. The

magico-theosophical philosophy, as Madame Blavatsky expresses it, is fully indicated in his work, and he proved to be the warmest defender of the doctrines of occult magnetism, of which he was one of the first propounders.

REFERENCES.—" Biog. Générale," Vol. XXXVII. pp. 514–518; P. Hallé, " Gab. Naudé Elogium "; N. Sanson, " Hist. Chr. d'Abbeville," 1653; Sainte Beuve, " Portraits Littéraires," 1855; Alf. Franklin, " Hist. de la Biblioth. Mazarine," 1860.

A.D. 1627.—Hakewill (George), Archdeacon of Surrey, publishes at Oxford, England, the first edition of " An Apologie or Declaration of the Power and Providence of God," the tenth chapter, fourth section of the third book of which alludes to the use of the " mariner's compass or sea-card, as also of another excellent invention sayd to be lately found out upon the loadstone." As the reviewer justly observes: " While perusing his description one can hardly imagine that the writer had not in his mind's eye one of our modern telegraphic instruments . . . and it will be seen that the date at which his work is written was nearly two hundred years prior to the first attempt made to communicate at a distance by means of magnetic needles."

Hakewill alludes ("Apologie," 1635, lib. ii. p. 97) to Hipparchus—Abraxis—" who reports that, in his time, the starre commonly called the Polar Starre, which is in the tayle of the lesser Beare, was twelve degrees and two-fifths distant from the Pole of the Æquator. This starre, from age to age, hath insensibly still crept nearer to the pole so that at this present it is not past three degrees distant from the pole of the Æquator. When this starre then shall come to touch the Pole, there being no farther place left for it to go forward (which may well enough come to pass with five or six hundred yeares) it is likely that then there shall be a great change of things, and that this time is the period which God hath prefixed to Nature " (see Morell's " Elem. . . . Phil. and Sc.," London, 1827, pp. 116–119 *et seq.*).

Mention of the star in the tail of Ursa Major is made by Gilbert, (" De Magnete "),[1] in connection (1) with Marcilius Ficinus, who, says he, seeks in that constellation the cause of the magnetic direction, as he believes that in the loadstone the potency of Ursa prevails and hence is transferred to the iron; (2) with Cardan, who assigns the cause of variation to its rising, for he thinks variation is always to be relied upon at the rising of the star; (3) with Lucas Gauricus, who holds that the loadstone beneath the tail of Ursa Major is ruled by the planets Saturn and Mars; (4) with Gaudentius Merula, who

[1] At the first chapter of Books I., III. and IV.

believes that the loadstone draws iron and makes it point North because it is of a higher order than is the iron in the Bear.

REFERENCES.—Larousse, "Dict. Univ.," Vol. IX. p. 26; "Dict. of Nat. Biog.," Vol. XXIV. pp. 6–8; Walton and Cotton, "Complete Angler," New York and London, 1847, Part I. p. 118.

A.D. 1628.—Leurechon (Jean), a student belonging to the Order of Jesuits (1591–1670), who became the confessor of Charles IV of Lorraine, publishes, under the name H. Van Etten, "La Récréation Mathématique," carefully revised editions of which were made by Claude Mydorge and Denis Henrion in 1630, 1638 and 1661. In these, Leurechon alludes to the reported transmission of intelligence by the agency of a magnet or other like stone, saying: "The invention is beautiful, but I do not think there can be found in the world a magnet that has such virtue."

REFERENCES.—Georges Maupin, "Opinions touchant la mathématique," Paris, 1898, pp. 20–24; Larousse, "Dict.," Vol. X. p. 436; "Sc. Am. Suppl.," Nos. 56, p. 881, and 384, p. 6125.

The curious title-page of the English version of Leurechon's work, published by T. Cotes in 1633, merits reproduction: "Mathematicall Recreations, or a Collection of sundrie Problemes, extracted out of the Ancient and Moderne Philosophers, as secrets in nature, and experiments in Arithmeticke, Geometrie, Cosmographie, Horologographie, Astronomie, Navigation, Musicke, Optickes, Chimestrie, Waterworkes, Fireworks, etc., Fit for Schollers, Students, and Gentlemen . . . lately compiled in French by Henry Van Hetten. And now delivered in the English tongue."

Claude Mydorge, as stated in the "Biog. Gén.," Vol. XXXVII. p. 87, was a French scientist (1585–1647), a very close friend of Descartes, and, according to Baillet, was next to Vieta, the foremost mathematician of his day. The second edition of his "Examen du livre des Récréations Mathématiques (du Père Leurechon)," contains notes of Denis Henrion following the observations of Père Mersenne in "Universæ . . ." Paris, 1639 (see Bouillet, "Vie de Descartes," Vol. I. pp. 36–37, 149–150, and Vol. II. pp. 43, 76, 78, 325).

Denis Henrion was also a French mathematician, who died about 1640. He was the author of many very meritorious papers, notably of a "Traité des Globes et de leurs usages," 1618, translated from the Latin of Robert Hues, 1593, 1594 (Larousse, "Dict. Univ.," Vol. IX. p. 192).

A.D. 1629.—Cabæus—Cabeo (Nicolaus), a learned Jesuit of

Ferrara, describes ("Philosophia Magnetica")[1] numerous experiments made by him to ascertain the possibility of two persons communicating intelligence by means of magnetized needles.

Cabæus was the first to observe electrical repulsion, and he thus announces his discovery in the tenth chapter of the above-named work: "Magnetic attractions and repulsions are physical actions which take place through the instrumentality of a certain quality of the intermediate space, said quality extending from the influencing to the influenced body. . . . Bodies are not moved by sympathy or antipathy, unless it be by means of certain forces which are uniformly diffused. When these forces reach a body that is suitable they produce changes in it, but they do not sensibly affect the intermediate space nor the non-kindred bodies close by it. . . ."

The "Philosophia Magnetica" is the second Latin book published on electricity, Gilbert's "De Magnete" being the first.

REFERENCES.—Becquerel, "Résumé," Chap. III; Stuello, "Bibl. Scrip. S. J.," Rome, 1676; Francisco de Lanis, "Magist. nat. et artis," 1684; L. L. de Vallemont, "Description de l'aimant," 1692, pp. 167, 170; Dechales C. F. Milliet, "Cursus seu Mundus Mathem.," 1674, 1690.

A.D. 1632.—Sarpi (Pietro)—Fra Paolo Sarpi—Father Paul—Paulus Venetus—Paolo Sarpi Veneto (*b.* 1552, *d.* 1623), who was the author of the celebrated history of the Council of Trent ("the rarest piece of history the world ever saw") is referred to by Gilbert in "De Magnete," Book I. chap. i. Therein, he says that Baptista Porta, who has made the seventh book of his "Magia Naturalis" a very storehouse and repertory of magnetic wonders, knows little about the movements of the loadstone and never has seen much of them, and that a great deal of what he has learned about its obvious properties, either through Messer Paolo, the Venetian, or through his own studies, is not very accurately noted and observed.

In the introduction to the 1658 edition of his "Natural Magick," Porta admits that he gained some knowledge of Sarpi, who, says he, is of all men he ever knew the most learned and skilful and the ornament and splendour not only of Venice or of Italy, but of the entire world. Bertelli refers ("Memor. sopra P. Peregrino," p. 24, note) to P. Garbio's "Annali di Serviti," Lucca, 1721, Vol. II. pp. 263, 272, 274, and to Fra Fulgenzio Micanzio's "Life of Sarpi," Helmstat—Verona, 1750, in which it is stated that not only Porta but likewise

[1] "Philosophia magnetica in qua magnetis natura penitus explicatur. . . ." An important work on the loadstone, in which the author often confutes the published treatise of Dr. Gilbert of Colchester, and quotes the inedited writings of L. Garzoni, who, even before Gilbert, had made researches respecting the magnet. A curious chapter in the "Philosophia" institutes a comparison between electrical and magnetical attraction (Libri, "Catalogue," 1871, Part. I. p. 161).

a celebrated *ultramontane* studied magnetism under him. Garbio asks : " Could this *ultramontane* be Gilbert of Colchester ? "

By Griselini (" Vita de Fra P. Sarpi "—memoria anecdote—Lausanne, 1760), Paolo is said to have written a treatise on the magnet and to have therein recorded many observations, including the earliest mention that magnetic properties are destroyed by fire.

Bertelli—whose afore-named memoir we must confine ourselves to, as it is more satisfactory than are the accounts elsewhere given—makes mention that he has had in his possession, by courtesy of Sig. Giuseppe Valentinelli, the Royal Librarian of the Marciana at Venice, copy of a manuscript (Cod. CXXIX, classe 2, MS. Ital.) containing a brief comparison of Sarpi's magnetic researches with those of Musschenbroek. This manuscript is again alluded to by Bertelli (Memor., p. 88) wherein it is said that lines 5–38 of the first column, p. 170, are headed " Observations of F.P.S. on the loadstone, collated with P. Musschenbroek's Researches," and embrace five paragraphs translated as follows :

1. The author had first tried the action of one magnet on another without entering into the question of calculation, but modern authors have, in view of the observations made, endeavoured to discover a method of computing magnetic forces in any proportion to the distances, and in the same better regulated systems they have discovered the cause to be uncertain (or varying) owing to the contemporaneous action of magnetic repulsion.
2. He was acquainted with the well-known action of the magnet on iron, but he understood—as even at this day some understand—that it was caused by the atmosphere. New experiments have made us seriously doubt this. He did not pay attention to the proportion of the magnetic forces as compared with the distances of iron, to the discovery of which the efforts of present philosophers are directed but in vain. He saw, however, that the facility or difficulty of attraction depends upon the size of the iron (maximum and minimum).
3. He was not ignorant of the direction of the magnet and of iron rubbed with the magnet towards certain quarters of the sky when he mentions the new discovery of the poles in the magnet, and the variation of the magnetized needle, from the Northern or the Southern quarters, but he did not know a greater number than two poles found in the magnet, the variation of the declination, or, I should rather say, the uncertainty of the variation and the different inclinations of the needle at different places on the earth.

4. Almost all the experiments referred to by Academies, with reference to the action of one piece of iron on another piece of iron, magnetized and not magnetized, and with regard to the changes of forces which arise from the various inflections of iron, have been sufficiently sketched out by F. P. S.
5. The magnetic effects acquired by an old piece of iron continually exposed to the air have also been alluded to. Now, however, natural philosophers have observed that this iron exposed for a length of time in the magnetic meridian points with greater readiness to the above-mentioned quarters. They have, moreover, ascertained that iron when heated and afterwards cooled in water is more sensitive to magnetization : which is directly opposed to the opinion of F. P. S.

Bertelli further remarks that, from information given in the manuscript, it is seen that Sarpi was at that time acquainted with the greater number of the magnetic phenomena referred to by Porta, and developed by Gilbert, viz. :

1. The reciprocal action of magnets;
2. The action of magnets on iron;
3. The manifestation of magnetic activity about the poles (sphere of action or field of force);
4. The *Maximum* and the *Minimum* of the attractive force of magnets on iron, according to the size of the latter;
5. The inversion of polarity which may arise in the magnetization of needles—(but not the corresponding poles—the magnetic variation or declination—Petrus Peregrinus, A.D. 1269—yet not the variation of the variation—Henry Gellibrand, A.D. 1635—nor the dip or inclination—Robert Norman, A.D. 1576).
6. The magnetic properties acquired by iron constantly exposed to the air.

After detailing the observations of Giulio Cesare Moderati, Filippo Costa (Costæus) of Mantua, Ulysses Aldrovandi, Francesco Acoromboni, Luigi Matteini, Father Garzoni and Father Cabæus concerning the magnetized ironwork of the belfry of the church of St. Augustine at Arimini (the parochial church of St. John the Baptist, which at that time, 1586, belonged to the monks of St. Augustine) and relative to the iron rail in the belfry of the tower of St. Laurence at Rome, Bertelli says : " From all that precedes, we gather at all events, that the fact of the spontaneous magnetization of iron was well known in Italy before Sarpi, Porta and Gilbert. This, Gilbert, and still better Cabæus, explained as the influence of

terrestrial magnetism. However, with regard to the observations of the needle's deviation made by Father Garzoni at Rome, we can, without having attributed it, as does Cabæus, to the magnetization of pieces of iron concealed in its wall, explain it, as is done in the new and important experiments of the illustrious professor Silvestro Gherardi, who attributes it to the magnetic polarity of the *Mattoni* [bricks] in the structure itself."

It is said by Humboldt (" Cosmos," 1849, Vol. II. p. 718, note) that this observation, the first of the kind, was made on the tower of the church of the Augustines at Mantua (Mantova) and that Grimaldi and Gassendi were acquainted with similar instances (instancing the cross of the church of St. Jean, at Aix, in Provence), in geographical latitudes where the inclination of the magnetic needle is very considerable. Some writers give Gassendi's observation as occurring during 1632 (see Rohaulti, " Physica," 1718, Par. III. cap. 8, p. 399; or, Rohault's " System of Nat. Phil.," 1728, p. 176).

" As the iron cross of an hundred weight upon the Church of St. John in Ariminum, or that load-stoned iron of Cæsar Moderatus, set down by Aldrovandus " (Sir Thomas Browne, "Pseudodoxia Epidemica," 1658, p. 66).

Consult " Lettera dell' Eccel. Cavallara.," Mantova, 1586, for a detailed account of this discovery, made January 6, of the last-named year. The iron rod supported a brick ornament in the form of an acorn, and stood on a pyramid at the summit of the belfry of the church of St. Augustine (Cabæus, " Philos. Magn.," p. 62; " Ulysses Aldrovandi, Patr. Bonon . . . Barthol. Ambros . . ." Lib. i, cap. 6, p. 134).

For the account given by Aldrovandi of the Arimini observation and for references to Browne's " Pseudodoxia Epidemica," as well as to Boyle's " Experiments," see p. 53 of the valuable " Notes on the 'De Magnete' of Dr. William Gilbert," by Silvanus P. Thompson, attached to the English translation of the original 1600 edition, which was so attractively produced by the Gilbert Club during the year 1900. Dr. Thompson further gives, at the page following (54), additional references to examples of iron acquiring strong permanent magnetism from the earth.

REFERENCES.—Biography of Sarpi in the " Encycl. Brit.," ninth edition, Vol. XXI. pp. 311–313; F. Micanzio, " Vita de F. P. Sarpi," Verona, 1750; Rev. Alex. Robertson, " Fra Paolo Sarpi—the greatest of the Venetians," 1894; Hallam, " Intro. to Lit.," 1839, Vol. II. p. 464; U. Aldrovandi, " Musæum Metallicum," 1648, p. 134; Tiraboschi, " Storia della Lettera," Modena, 1794, Vol. VI. part ii. p. 506; Sarpi's Complete Works, first published at Helmstat, 1750; Fabroni, " Vitæ Italorum," Pisa, 1798; Giovini, " Vita," Brussels, 1836; " Engl. Cycl.,"

Biography, Vol. IV. pp. 695–697; Larousse, " Dict. Univ." Vol. XIV. pp. 230–231; " History of the reign of Charles the Fifth," by Wm. Robertson and Wm. H. Prescott, Philadelphia, 1883, Vol. III. p. 68; " Dict. Hist. de la Médecine," N. F. J. Eloy, Mons, 1778, Vol. IV. pp. 180–181; " The Atlantic Monthly," New York, January and February, 1904, wherein the author, Andrew D. White, ranks Sarpi with Machiavelli and Galileo; Libri, " Hist. des Sc. Mathém." Paris, 1838, Vol. IV. p. 214, note.

A.D. 1632.—Gassendi (Pierre), an eminent French savant, professor at the Royal College of France, " ranked by Barrow among the most eminent mathematicians of the age, and mentioned with Galileo, Gilbert and Descartes," discovers that a part of the iron cross of the Church of St. Jean at Aix possesses all the properties of a loadstone after being struck by lightning and lying in one position a certain length of time. Gilbert mentions, " De Magnete," 1600, Book III. chap. xii.) that the fact of magnetism being imparted to an iron bar by the earth was first ascertained by examining the rod upon the tower of the church of St. Augustine at Arimini (Sir Thomas Browne, " Pseud. Epidemica," London, 1650, p. 48; U. Aldrovandi, " Musæum Metallicum," Milan, 1648, p. 134).

In the " Vie de Pierre Gassendi," par le Père Bougerel de l'Oratoire, Paris, 1737, p. 14, it is related that during the month of September 1621, while promenading about three leagues' distance from Aix in a village named Peynier, he observed a light in the heavens to which he gave the name of *aurora borealis*, as much on account of its location as by reason of its resemblance to the light which precedes the rising of the sun.

From the " History of the Royal Society," by C. R. Weld, 1848, Vol. II. p. 430, is taken the following, communicated by Humboldt:

" The movement of the magnetic lines, the first recognition of which is usually ascribed to Gassendi, was not even yet conjectured by William Gilbert; but, at an early period, Acosta, ' from the information of Portuguese navigators,' assumed four lines of no declination upon the surface of the globe. . . . In the remarkable map of America appended to the Roman edition of the Geography of Ptolemy in 1508, we find, to the north of Gruentland (Greenland), a part of Asia represented and the magnetic pole marked as an insular mountain. Martin Cortez, in the ' Breve Compendio de la Sphera ' (1545), and Livio Sanuto, in the ' Geographia di Tolomeo ' (1588), place it more to the south. Sanuto entertained a prejudice, which, strange to say, has existed in later times, that a man who should be so fortunate as to reach the magnetic pole (*Il calamitico*) would then experience *alcun miracoloso stupendo*

effecto" ("Cosmos," translated under the superintendence of Col. Sabine, Vol. II. p. 280). In a footnote to the Otté translation of Humboldt, 1859, Vol. V. p. 58, it is stated that *calamitico* was the name given to the instruments in consequence of the first needles for the compass having been made in the shape of a frog.

In Gilbert's "De Magnete," allusion is made to Martinus Cortez, Book I. chap. i., also Book III. chap. i. and Book IV. chap. i.,[1] and to Livio Sanuto in Book I. chap. i., also in Book IV. chaps. i. and ix. In these several passages, Gilbert tells us that Martinus Cortez holds the loadstone's seat of attraction to be beyond the poles, and he states the views of other writers in this respect, citing more particularly T. de Bessard (author of "Le Dialogue de la Longitude"), Jacobus Servertius (who wrote "De Orbis Catoptrici"), as well as Robert Norman, Franciscus Maurolycus, Marsilio Ficino, Cardan, Scaliger, Costa and Petrus Peregrinus (M. J. Klaproth, "Lettre à M. le Baron de Humboldt," Paris, 1834, pp. 16–17, 37).

References.—Enfield, "Hist. Phil.," Vol. III. p. 430; "Le Cosmos" for May and June 1859, containing a very interesting series entitled, "Les Armées Météores"; Lardner, Vol. II. p. 113; Humboldt, "Cosmos," 1859–1860, Vol. II. p. 335, and Vol. V. pp. 146–153; Julius Cæsar at A.D. 1590; Houzeau et Lancaster, Vol. II. p. 146; "Mém. de l'Acad. Royale des Sciences," Vol. X. p. 737; "Phil. Hist. and Memoirs of the Royal Acad. of Sc.," Vol. II. p. 281; "Geschichte der Mathematik," Vol. IV. p. 474.

A.D. 1632.—Galileo (Galileo Galilei), Italian philosopher and mathematician, publishes his celebrated "Dialogo sopra i due massimi sistemi del mondo tolemaico e copernicano," 4to, Fiorenza, from p. 88 of which is extracted the following passage:

Sagredus: "You remind me of a man who offered to sell me a secret for permitting one to speak, through the attraction of a certain magnet needle, to someone distant two or three thousand miles, and I said to him that I would be willing to purchase it, but that I would like to witness a trial of it, and that it would please me to test it, I being in one room and he being in another.

[1] It is in the afore-mentioned Book IV. chap. i. that Gilbert makes mention of Norumbega, "the lost city of New England," regarding which latter very interesting particulars will be found in the following publications: "Magazine of Amer. Hist." for 1877, pp. 14, 321, and for 1886, p. 291; "New England's Lost City Found"; Lang's "Sagas of the Kings of Norway"; "Antiquitates Americanæ," Royal Soc. of Copenhagen; Shea's "Catholic Church in Colonial Days"; "Narrative and Critical History of America," by Justin Winsor, Boston, 1889, Vol. II. pp. 451, 453, 459, 472; Vol. III. pp. 169–218; Vol. IV. pp. 53, 71, 88, 91–99, 101, 152, 373, 384; Vol. V. p. 479; R. Hakluyt, "The Principal Navigations," Edinburgh, 1889, Vol. XIII. p. 162, note; J. G. Bourinot, "Canada," London, 1897, p. 28; Horsford, "Cabot's Landfall in 1497, and the site of Norumbega"; "Discovery of the Ancient City of Norumbega"; also "Defences of Norumbega."

He told me that, at such a short distance, the action could not be witnessed to advantage; so I sent him away and said that I could not just then go to Egypt or Muscovy to see his experiment, but if he would go there himself I would stay and attend to the rest in Venice."

This *Sagredus* (Iohannes Franciscus), or Sagredo (Giovanni Francisco), besides being " a great magneticall man," was a noble Venetian, even a doge, and had represented his country as ambassador at several courts. We read in Mr. Conrad W. Cooke's very able article on William Gilbert of Colchester, originally printed in London " Engineering," that this same *Sagredus* was the intimate friend of Galileo, and that, together with the powerful Sarpi, he used the whole might of his name and influence to protect the great philosopher and mathematician from the attacks of the clerical party. Pietro Sarpi, otherwise known as Father Paul, was, as already shown, a most illustrious Venetian scholar, who attained great proficiency in the medical and physiological sciences as well as in mathematics and in natural philosophy. *Sagredus* made several meritorious researches in magnetism, and, while on a voyage to Aleppo, ascertained the declination of the magnetic needle at that place. As a tribute to the scientific attainments of *Sagredus*, Galileo gave his name to one of the characters in his " Systema Cosmicum," and many references to the work by William Gilbert are put into the mouth of *Sagredus*.

In further illustration of Galileo's appreciation of Gilbert, the following is quoted from the great astronomer's own writing: " I extremely admire and envy the author of ' De Magnete.' I think him worthy of the greatest praise for the many new and true observations which he has made, to the disgrace of so many vain and fabling authors, who write not from their own knowledge only, but repeat everything they hear from the foolish and vulgar, without attempting to satisfy themselves of the same by experience; perhaps that they may not diminish the size of their books " (Drinkwater's " Life of Galileo ").

Galileo had also published, in 1630, the first edition of his " I discorsi e demonstrazioni . . ." which Lagrange considers to be Galileo's most substantial title to scientific glory.

References.—Galileo's Biography in " Engl. Cycl.," Vol. III. pp. 13–17; Miller, " Hist. Phil. Illust.," London, 1849, Vol. III. p. 203, note; Nelli, " Vita," 1793; Libri, " Hist. des Sc. Math.," Paris, 1838, Vol. IV. pp. 157–294, 473–484; Houzeau et Lancaster, " Bibliog. Générale," Vol. I. part i. pp. 655–657 for an analyzation of the works of Galileo, also Vol. II. pp. 137–145, 1576–1578; Wm. Whewell, " Phil. of the Ind. Sc.," London, 1840, Vol. II. pp. 379–383; Guillaume Libri, " Histoire des Sc. Math.," Halle, 1865, Vol. IV. pp. 157–302, and the notes;

"Journal des Savants" for September and October 1840, for March and April 1841, for July to November 1858, for September 1868 and for October 1877; "Geschichte der Mathem.," Vol. IV. pp. 4, 173, etc.; Larousse, "Dict.," Vol. VIII. p. 954; "La Grande Encycl.," Vol. XVIII. pp. 383–385; "Biog. Gén.," Vol. XI. pp. 252–267; Fabroni (A.), "Vitæ Italorum," 1778–1805, also "Elogi d' Illustri Italiani," 1786–1789; likewise the very numerous entries concerning Galileo's history, his Opponents, Supporters and School, which appear at pp. 331–357, Part I. of Libri's "Catalogue," published in 1861. Consult also "Galileo," by Ed. S. Holden, in the "Popular Sc. Monthly" for January, February, May and June 1905; "Bibliot. Brit.," Vol. XVI. N.S., 1821, pp. 3–21, 79–100, for an account of the life of Galileo by M. G. B. Clément de Nelli; "Journal des Sçavans," Vol. LXX. for 1721, p. 350 in his "Saggiotore"; "Imperial Dictionary of Universal Biography," published by Wm. McKenzie, London, pp. 536–539, giving an account of Galileo's other discoveries.

A.D. 1635.—Delambre (J. B. J.) (1749–1822), professor of astronomy at the Royal College of France, refers (Vol. II. p. 545 of his "Histoire de l'Astronomie Ancienne," 1817) to the mention made in "Procli Diadochi Paraphrasis Ptolem.," lib. iv. "de siderum effectionibus," 1635, p. 20, of the notion long current, especially along the shores of the Mediterranean, "that if a magnetic rod be rubbed with an onion, or brought into contact with the emanations of the plant, the directive force will be diminished, while a compass thus treated would mislead the steersman."

References.—Humboldt, "Cosmos," 1859, Vol. V. p. 156, also the entry at A.D. 1653. See likewise Whewell, "Hist. of the Ind. Sc.," Vol. I. pp. 442, 443, 447, and the biography in the Supplement of the "English Cyclopædia," pp. 539–541; "Journal des Savants," for April 1828.

A.D. 1635.—Gellibrand (Henry), prominent English mathematician, professor of geometry and the successor of Edmund Gunter (A.D. 1624), in the chair of astronomy at Gresham College, publishes his discovery of the *secular variation of the declination.* The credit of this discovery has been by many given to John Mair. The *diurnal and horary variation* was found by Graham in 1722, and the *annual variation* was discovered by Cassini, 1782–1791.

Gellibrand's discovery is published in a small quarto pamphlet entitled "A discourse mathematical on the variation of the magneticall needle—together with the admirable diminution lately discovered," and is the result of his study of the observations made by Burrough and Gunter as well as of observations made by himself, all showing that the north-east of the needle was gradually moving to the westward.

Mention has already been made of the fact that the *variation of the variation* was at this period attracting the attention it deserved, and it is worth while giving here an account of the discovery in the author's own words:

"Thus, hitherto, according to the Tenents of all our Magnetical Philosophers, we have supposed the variations of all particular places to continue one and the same. So that when a Seaman shall happly return to a place where formerly he found the same variation, he may hence conclude he is in the same former longitude. For it is the assertion of Mr. Dr. Gilbert's *Variatio unicuiusq ; loci constans est,* that is to say, the same place doth always retaine the same variation. Neither hath this assertion, for ought I ever heard, been questioned by any man. But most diligent magneticall observations have plainely offered violence to the same, and proved the contrary, namely, that the variation is accompanied with a variation."

A.D. 1637.—Bond (Henry), Professor of Mathematics in London, and who appears in one of his treatises as "a famous teacher of the art of navigation," is the author of the "Sea-man's Kalendar . . . with a discovery of the . . . secret of longitude . . ." of which other editions appeared during 1640 and 1696.

This was followed by many papers on the variation (the most important of which are to be found in *Phil. Trans.* for 1668, 1672, 1673) and, during 1678 by "The Longitude not found, or an answer to a treatise written by H. B. . . ." This treatise was in a sixty-five page pamphlet which had been issued by Mr. Bond's father during 1676, under caption : "The Longitude Found; or a treatise shewing an easie and speedy way, as well by Night as by Day, to find the Longitude, having but the Latitude of the Place and the Inclination of the Magneticall Inclinatorie Needle . . ." wherein he explains his discovery of the progress of the deviation of the compass and foretells the variations for London, 1663 to 1716. This treatise led to the controversy with Peter Blackborrow (Beckborrow), the title to whose published work reads : "The Longitude not found : or an answer to a treatise written by H. Bond, senior, shewing a way to find the longitude by the magnetical inclinatory needle : wherein is proved that the longitude is not nor cannot be found by the magnetic inclinatory needle."

As Humboldt remarks, the resulting controversy, together with Acosta's view that there were four lines of no variation which divided the earth's surface, may, as already stated, have had some influence on the theory advanced, in 1683, by Edmund Halley, of four magnetic poles or points of convergence ("Cosmos," 1859–1860, Vol. I. p. 193, note; Vol. II. pp. 280–281, note; Vol. V. p. 58; also Humboldt's "Examen Critique de l'Histoire de la Géographie," Vol. III. p. 60. See likewise the *Phil. Trans.* for October 19, 1668, p. 790, and for 1673, Vol. VIII. p. 6065, also

following abridgments: Hutton, Vol. II. p. 78, and Lowthorp, Vol. II. p. 610).

REFERENCES.—Walker, "Magnetism," Chap. I; John Pell, "Letter of Remarks on Gellibrand's Math. Disc.," 1635; "Annales de Chimie et de Physique," Mars 1902, Vol. XXV. pp. 289–307; Humboldt, "Cosmos," 1859, Vol. V. pp. 61, 116; Whewell, "Hist. of the Ind. Sc.," 1859, Vol. II. p. 219; G. Hellmann, "Neudrucke vonschriften," No. 9; Baddam's abridgments of the *Phil. Trans.*, 1739, Vol. IV. p. 102.

A.D. 1641.—Wilkins (John), Bishop of Chester in the reign of Charles II, publishes the first edition of "Mercury, or the secret and swift messenger, showing how a man, with privacy and speed, may communicate his thoughts to a friend at any distance." [1]

In the above, he thus alludes to the possibility of making a contrivance similar to our modern phonograph: "There is another experiment . . . mentioned by Walchius, who thinks it possible so to contrive a trunk or hollow pipe that it shall preserve the voice entirely for certain hours or days, so that a man may send his words to a friend instead of his writing. There being always a certain space of intermission, for the passage of the voice, betwixt its going into these cavities and its coming out; he conceives that if both ends were seasonably stopped, while the sound was in the midst, it would continue there till it had some vent. *Huic tubo verba nostra insusurremus, et cum probe munitur tabellario committamus*, etc. When the friend to whom it is sent shall receive and open it, the words shall come out distinctly, and in the same order wherein they were spoken. From such a contrivance as this [saith the same author] did Albertus Magnus make his Image, and Friar Bacon his Brazen Head, to utter certain words."

In the eighteenth chapter, he makes suggestions for "a language that may consist of only tunes and musical notes, without any articulate sound."

He had previously described a novel mode of telegraphing by the use of only three torches (or lights), to designate the twenty-four letters of the alphabet. These letters were, according to the plan of Joachimus Fortius, to be placed in three classes of eight each. One torch indicated Class I, two torches Class II, three torches Class III, and the number of the letter was shown by the number of times a torch was elevated.

[1] "That which first occasioned this Discourse, was the reading of a little Pamphlet, stiled, *Nuntius Inanimatus* (by Dr. Francis Godwin); wherein he affirms that there are certain ways to discourse with a Friend, though he were in a close Dungeon, in a besieged City, or a hundred miles off. . . . After this, I did collect all such Notes to this purpose, as I met with in the course of my other Studies. From whence when I had received full satisfaction, I did for mine own further delight compose them into this method."—*The Author.*

Bishop Wilkins also described a method of telegraphing by means of two lights attached to long poles, which, he says, "for its quickness and speed is much to be preferred before any of the rest." To interpret messages at long distances, he suggested the use of the then newly invented telescope; which he called "Galileus his perspective."

References.—The third edition of above-named work, Chap. XVII. pp. 71, 72, also the fifth edition of Wilkin's "Mathematical Magick," London, 1707, Chap. XIII. pp. 147–150, "concerning several attempts of contriving a perpetual motion by magnetical virtues." Likewise Whewell, "Hist. of the Ind. Sc.," 1859, Vol. I. pp. 332, 395; Mendoza, "Tratado de Navegacion," Vol. II. p. 72; Alex. Chalmers, "Gen. Biog. Dict.," London, 1811, Vol. XXXII. pp. 74–82.

A.D. 1641.—Kircher (Athanasius), a German writer on physical and mathematical science (1601–1680), member of the Order of Jesuits, possessed of immense erudition and believing in the magnetism of all things, speaks in his "Magnes sive de arte magnetica" (Book II. pt. iv. chap. v.), of the recently advanced idea of being able to correspond at short distances by employing two spherical vessels bearing the letters of the alphabet, each of the letters having suspended from it a magnetized figure attached to a vertical wire.

He likewise alludes to Gellibrand's discovery, A.D. 1635, of which he was informed by John Greaves, the eminent English mathematician, and he communicates a letter received from the learned French philosopher, le Père Marin Mersenne, containing a distinct account of the same.

His definition of universal magnetism, according to Madame Blavatsky, is very original, for he contradicted Gilbert's theory that the earth was a great magnet. He asserted that, although every particle of matter and even the intangible "powers" were magnetic, they did not themselves constitute a magnet. *There is but one Magnet in the universe, and from it proceeds the magnetization of everything existing.* This magnet is, of course, what the Kabalists term the central Spiritual Sun, or God. . . . He demonstrates the difference between mineral magnetism and zoömagnetism, or animal magnetism, and says that the sun is the most magnetic of all bodies. . . . It imparts the binding power to all things falling under its direct rays ("Isis Unveiled," pp. 208–210).

Another Jesuit, Jacobo Grandamico (1588–1672), published in 1645, "Nova demonstratio immobilitatis terræ petita ex virtute magnetica," wherein he shares fully the views of Niccolas Cabæus, Athanasius Kircher, Vincentus Leotaudus and others of the same Order relative to the earth's magnetism (Larousse, "Dict.," Vol. VIII. p. 1445).

References.—"Journal des Sçavans" pour 1665 et 1666, pp. 519–525, 571–578; "Nouveau Larousse," par Claude Augé, Paris, Vol. V. p. 485; "Salmonsen . . . konversationsleksikon," 1900, p. 480; Van Swinden, "Recueil," 1784, Vol. II. pp. 352, 361, 394, and the different works named in Ronalds's "Catalogue," pp. 266–267; ninth ed. "Encycl. Brit.," Vol. XIV. pp. 93–94.

A.D. 1644.—Digby (Sir Kenelme), the very famous Englishman to whom allusion has already been made under the B.C. 600–580 entry, publishes, in Paris, "Two Treatises, in the one of which the Nature of Bodies: in the other, the nature of Man's Soule is looked into: in Way of Discovery of the Immortality of Reasonable Soules."[1] In a chapter of this work, entitled "Of the loadstone's generation and its particular motions," appears the following interesting reference to Gilbert's work and reputation: "But to come to experimentall proofes and obseruations vpon the loadstone by which it will appeare that these causes are well esteemed and applyed, we must be beholding to that admirable searcher of the nature of the loadstone, Doctor Gilbert: by means of whom and of Doctor Haruey, our nation may claim euen in this latter age as deserued a crowne for solide Philosophicall learning as for many ages together it hath done formerly for acute and subtile Speculations in Diuinity. But before I fall to particulars, I thinke it worth warning my Reader, how this great man arriued to discouer so much of Magneticall Philosophy; that he, likewise, if he be desirous to search into nature, may, by imitation, advance his thoughts and knowledge that way. In short, then, all the knowledge he gott of this subject was by forming a little loadstone into the shape of the earth. By which meanes he compassed a wonderful designe, which was to make the whole globe of the earth maniable; for he found the properties of the whole earth in that little body; which he therefore called a Terrella, or little earth; and which he could manage and trye experiences vpon att his will. And, in like manner, any man that hath an ayme to aduance much in naturall sciences, must endeauour to draw the matter he inquireth of, into some such modell, or some kinde of manageable methode; which he may turne and winde as he pleaseth. And then lett him be sure, if he hath a competent vnderstanding, that he will not misse of his marke."

References.—"The Private Memoirs of Sir Kenelme Digby, Gentleman of the Bedchamber of King Charles I," London, 1827; "Dict.

[1] In the second edition of Digby's "The Immortality of Reasonable Soules" ("a treatise on the soul proving its immortality"), published during the year 1645, are to be found attractive portraits of himself and of his wife, Venetia Anastasia Stanley, daughter of Sir Edward Stanley, of Tongue Castle, one of the celebrated beauties of her day.

of Nat. Biog.," Vol. XV. pp. 60–66; "New Gen. Biog. Dict.," London, 1850, Vol. XI. p. 390; "Gen. Biog. Dict." of Alex. Chalmers, London, 1811, pp. 70–78; "Emerson's Works," London, 1873, Vol. II. p. 35; "The Library" for April 1902, has, at pp. 131–132, the arms of the Digbys.

A.D. 1644.—Descartes (René), a prominent French philosopher and mathematician, publishes his "Principia Philosophiæ," divided into four parts; the first giving an exposition of the principles of all human knowledge, the second treating of the principles of natural things, and the third and fourth parts developing his theory of vortices. His main idea was that a rush of subtle matter passes very rapidly through the earth from the equator towards each pole, being opposed by magnetic substances throughout its passage and that the sun is the centre of a vortex of an ethereal fluid, whose whirling motion produces the revolution of planets about the sun, or around the fixed stars. Moreover, as Noad states it, "the vortex moves with the greatest facility in a particular direction, one of its ends being always turned toward the north."

One of the most prominent fellow-students of Descartes was Marin Mersenne, who joined the religious Order of "Minimes," and who, after publishing in 1634 and 1639 "Les Mécaniques de Galilée" and "Nouvelles Découvertes de Galilée," brought out, during the years 1644 and 1647, his well-known "Cogitata phisico-mathematica," which, Montucla says, contains *un océan d'observations de toutes espèces* . . . and embraces a very interesting treatise on navigation besides many letters from leading scientists of that period not elsewhere to be found.

References.—"La grande Encyclopédie," Vol. XXIII. pp. 730–731; Larousse, "Dict.," Vol. XI. p. 94; "Biographie Générale," Vol. XXXV. pp. 118–123; "The English Cyclopædia," Vol. IV. p. 206; Alex. Chalmers, "Gen. Biog. Dict.," London, 1811, Vol. XXII. pp. 81–83; "Biographie Universelle," Vol. X. pp. 465–473; Whewell, "Hist. of the Ind. Sc.," Vol. I. pp. 323, 328, 338, 339, 343, 354, 387, 423, 429, 430; Vol. II. p. 220; likewise pp. 320 and 390 of Vol. I. relative to Le Père Marin Mersenne and pp. 391 and 423 concerning the "Traité de Physique" of James Rohault; Playfair's Fourth Dissertation in the eighth edition of the "Encycl. Britann."; "Essai théorique . . . des connaissances humaines," par G. Tiberghien, Bruxelles, 1844, Vol. I. pp. 472–495; Dr. W. Windelband, "History of Philosophy," New York, 1893, pp. 380–381, 391–396; Dr. F. Ueberweg, "History of Philosophy," New York, 1885, Vol. II. pp. 41–55; Alfred Weber, "History of Philosophy," translated by Frank Thilly, New York, 1896, pp. 305–323; Ruard Andala, "Descartes in reality the overturner of Spinosism and the architect of experimental Philosophy"; Erasmus Bartholinus, "De Cometis," Copenhagen, 1664–1665 ("Biog. Univ."; Weidler, p. 508) Mahaffy, 1880; Houzeau et Lancaster, "Bibl. Gen.," Vol. II. for Descartes, p. 119, and for Mersenne, p. 204; "Journal des Savants" for Feb. 1826, p. 103, for Feb. 1827, p. 110, also for Aug.–Oct. 1850, Dec. 1860, Jan.–Feb. 1861, Oct.–Nov. 1869, Feb. April and July 1870, Mar.–April 1880, Aug. 1884, April 1898, Feb. 1899.

A.D. 1646.—Browne (Sir Thomas), an eminent English physician and writer, publishes the well-known treatise "Pseudodoxia Epidemica, or Inquiries into Vulgar and Common Errors," which ran through six editions in twenty-seven years, and upon which his fame is principally established.

With regard to the possibility of such a magnetic telegraph as Strada speaks of he says (Book II. chap. iii.): "The conceit is excellent and, if the effect would follow, somewhat divine; whereby we might communicate like spirits, and confer on earth with Menippus in the moon. And this is pretended from the sympathy of two needles, touched with the same loadstone, and placed in the centre of two abecedary circles or rings, with letters described round about them, one friend keeping one and another keeping the other, and agreeing upon the hour when they will communicate, at what distance of place soever, when one needle shall be removed unto another letter, the other, by wonderful sympathy, will move unto the same."

As the result of experiment, he found that "though the needles were separated but half a span, when one was moved the other would stand like the pillars of Hercules, and if the earth stand still, have surely no motion at all. . . . By electrical bodies," he says, "I understand not such as are metallical, mentioned by Pliny and the ancients; for their *electrum* was a mixture made of gold, with the addition of a fifth part of silver; a substance now as unknown as true *aurichalcum*, or *Corinthian* brass, and set down among things lost by Pancirollus. Nor by electric bodies do I imagine such only as take up shavings, straws and light bodies, amongst which the ancients placed only *jet* and *amber*, but such as, conveniently placed unto their objects, attract all bodies palpable whatsoever. I say conveniently placed, that is, in regard of the object, that it be not too ponderous or any way affixed; in regard of the agent, that it be not foul or sullied, but wiped, rubbed and excitated; in regard of both, that they be conveniently distant, and no impediment interposed. I say, all bodies palpable, thereby excluding fire, which indeed it will not attract, nor yet draw through it, for fire consumes its effluxions by which it should attract."

The different chapters of this second book treat of the loadstone, of bodies magnetical and electrical, of magnetical rocks and attractive mountains, and also make allusion to the cross on the church of St. John in Ariminium, to the reported magnetical suspension of Mahomet's tomb, etc. etc.

At pp. 64, 81 and 87 of Chap. II he says: "Neither is it onely true, what Gilbertus first observed, that irons refrigerated North and South acquire a directive faculty; but if they be cooled upright and

perpendicularly, they will also obtain the same . . . Now this kind of practice, Libavius, Gilbertus and lately Swickardus, condemn, as vain and altogether unuseful; because a loadstone in powder hath no attractive power; for, in that form, it omits the polarity and loseth those parts which are the rule of attraction. . . . Glasse attracts but weakely though cleere, some slick stones and thick glasses attract indifferently; Arsenic not at all; Saltes generally but weakely, as Sal Gemma, Allum and also Talke, nor very discoverably by any frication; but, if gently warmed at the fire and wiped with a dry cloth, they will better develop their Electricities."

At Chapter XVII of the seventh book of the above-mentioned treatise, Browne makes allusion to "the story of Frier Bacon that made a Brazen Head to speak these words: "*Time is* . . ."

REFERENCES.—"Library of Literary Criticism," Chas. Wells Moulton, Vol. II. p. 339–345; "Fortnightly Review," for Oct. 1905, pp. 616–626, "Sir Thomas Browne and his Family"; Edmund Gosse, in the "English Men of Letters Series"; Browne's "Letter" inserted in the "Biographia Britannica," also his entire works, recognized as an encyclopædia of contemporary knowledge, and which were published in four octavo volumes by Simon Wilkins, F.S.A., London, 1836.

A.D. 1653.—In the third edition of "The Jewell House of Arte and Nature," by Sir Hugh Plat, originally published in 1594, and wrongly attributed in Weston's "Catalogue" to Gabriel Plattes, is to be found the following allusion to the loadstone: "And though the adamant be the hardest of all stones, yet is it softened with Goa's blood and there is a special antipathy between that and the loadstone, which is of the colour of rusty iron, and hath an admirable vertue not onely to draw iron to it self, but also to make any iron upon which it is rubbed to draw iron also, it is written notwithstanding that being rubbed with the juyce of Garlick, it loseth that vertue and cannot then draw iron, as likewise if a Diamond be layed close unto it."

This "special antipathy" of garlick, and of the diamond—whether or not the latter be softened with Goa's (goat's) blood—is treated of very fully by many other authors, notably:

Pliny, "Nat. Hist.," Holland tr. 1601, Chap. IV. p. 610; Plutarch, "Quæstones Platonicæ," lib. vii. cap. 7; Claudius Ptolemæus, "Opus Quadripartitum," lib. i. cap. 3; St. Augustine, "De Civitate Dei," lib. xxi.; Bartholom. de Glanvilla, "Liber de Proprietatibus Rerum," lib. xvi.; Pietro di Abano, "Conciliator Differentiarum," 1520, pp. 72–73, or the Venice edition of 1526, cap. 51; Joannes Ruellius, "De Natura Stirpium," 1536, pp. 125, 530; Ibn Roschd's "Comment on Aristotle," 1550, T. IV. p. 143*t*; Cardinal de Cusa, "Opera," 1565, p. 175; C. Julius Solinus, "De Memorabilibus," cap. 64; Walter Charleton, "A Ternary of Paradoxes," London, 1650, pp. 40–41; Thomas Browne, "Pseudodoxia Epidemica," 1658, p. 74; G. B. Porta, "Naturall Magi.k," 1658, Chap. XLVIII and Chap. LIII—from both of which chapters extracts

appear at the A.D. 1558 entry; "Journal des Savants" for January 1894; Chas. de Rémusat, "Hist. de la Philos.," Paris, 1878, Vol. II. p. 187.

Rohault—at p. 186 of his 1728 "Syst. of Nat. Phil."—says: "As to what some writers have related, that a loadstone will not attract iron if there be a diamond near and that onions and garlic will make it lose its vertue; these are contradicted by a thousand experiments which I have tried. For I have shown that this stone will attract iron through the very thickest diamonds and through a great many thick skins which an onion is made up of."

REFERENCES.—"Dict. of Nat. Biography," Vol. XLV. pp. 407–409, giving many particulars; J. B. J. Delambre, at A.D. 1635. For Gabriel Plattes, see the same "Dict. of Nat. Biography," Vol. XLV. p. 410.

A.D. 1657.—Schott (Gaspar)—P. Gaspar Schott—a German Jesuit who was sent to teach natural philosophy and mathematics at Palermo, Sicily, is the author of several very curious works on physics, of which the most important alone will here be noted.

"Magiæ Universalis Naturæ et Artis," etc., appeared at Herbipoli in 1657, 1658, 1659. In the first book of the fourth volume (or part) he indicates, according to Kircher, whom he had met while in Rome, the means of conveying one's thoughts at a distance by the loadstone, and he alludes to the speaking head constructed by Albertus Magnus, while, in the third and fourth books of the same volume, he gives a long treatise on the loadstone as well as an account of numerous experiments made with it.

"De Arte Mechanica," etc. ("Mechanicæ," etc.), Herbipoli, 1657–1658, contains, in Part II. class i. p. 314, the first published notice of Von Guericke's experiments.

"Physica Curiosa sive Mirabilia Naturæ," etc., Herbipoli, 1662 (which may justly be considered a continuation of the "Magiæ Universalis"), treats in the eleventh book of St. Elmo's fire, thunder and meteors in general.

"Technica Curiosa sive Mirabilia Naturæ," etc., Herbipoli, 1664, alludes, in the first two books, to the experiments made by Von Guericke and by Boyle, and gives the contents of eight letters written him by the first named.

"Schola Steganographica," etc., Norimbergæ, 1665, gives, at pp. 258–264, a description of the dial telegraph of Daniell Schwenter.

"Jocoseriorum Naturæ et Artis," etc., published about 1666, alludes to the "Thaumaturgus Mathematicus" of Gaspar Ens, published at Cologne, 1651, as well as to the "Deliciæ Physico-Mathematicæ" of Daniell Schwenter and Geo. Philippi Harsdoerffer (Senator of Nuremberg), to "La Récréation Mathématique" of

Jean Leurechon, and to the works of Cardan, Mizauld, Aldrovandi and others.

REFERENCES.—" Notice Raisonnée des Ouvrages de Gaspar Schott," par M. L'Abbé Mxxx de St. Léger de Soissons, Paris, 1785, pp. 6, 31, 32, 37, 44, 70; Muirhead's translation of Arago's Eloge de James Watt, London, 1839, p. 51.[1]

A.D. 1660.—Guericke (Otto von), a burgomaster of Magdeburg, Prussian Saxony, constructs the first frictional electric machine. It consisted of a globe of sulphur, cast in a glass sphere, and mounted upon a revolving axis, which when rubbed by a cloth pressed against it by the hand, emitted both sound and light. It was Guericke who " heard the first sound and saw the first light in artificially excited electricity." He proved that light bodies, when attracted by an excited electric, were immediately repelled by the latter and became incapable of a second attraction until touched by some other body; also that light bodies develop electrical excitation when suspended within the sphere of an excited electric.

REFERENCES.—" Experimenta Nova Magdeburgica," 1672, lib. iv, cap. 15, p. 147, also all relating to the sulphur globe reproduced from the " Experimenta Nova " at end of Figuier's " Exposition et Histoire," etc., Vol. IV. Paris, 1857; Moncony, Voyages, 1665; Schott (Gaspar), " Technica Curiosa," etc., Norimbergæ, 1664; " Abhandlungen zur Geschichte der Mathem.," Leipzig, 1898, Vol. VIII. pp. 69–112, for the two articles by Ferdinand Rosenberger on the development of the electric machine, etc., from the time of Von Guericke.

A.D. 1660.—At the meeting of the English Royal Society, held June 5, 1660, Magnetical Remedies were discoursed of. Sir Gilbert Talbot promised to bring in what he knew of *sympatheticall cures*, and those who possessed any *powder of sympathy* were requested to fetch some at the next meeting.

A.D. 1661.—Somerset (Edward), second Marquis of Worcester, an English inventor, announces, in his " Century of Inventions," that he has discovered " a method by which at a window as far as the eye can discover black from white, a man may hold discourse with his correspondent, without noise made or notice taken; being, according to occasion given, or means afforded, *ex re nata*, and no need of provision before-hand : though much better if foreseen, and course taken by mutual consent of parties." This method, he

[1] Libri says (" Catal.," 1861, Pt. II. p. 701) that the learned Jesuit, Schott, seems to have been very conversant with angels, for he not only dedicated his " Magia Naturalis " to an angel, but likewise another of his works, the " Magia Arithmetica," wherein he indicates the total *number of the angels* in existence, that number being composed of sixty-eight numerical figures.

asserts, he can put into practice " by night as well as by day, though as dark as pitch is black."

References.—Dircks' "Life of Worcester," p. 357; "Dictionary of National Biography," Vol. LIII. pp. 232–237.

A.D. 1662.—Rupert (Prince Robert), of Bavaria, son of Frederick V, elector palatine, and one of the founders of the Royal Society of London, is credited with the discovery of the curious glass bubbles called " Rupert's drops." These are merely drops of glass thrown, when melted, into water, and thus becoming suddenly consolidated into a shape somewhat resembling the form of a tear. The globular end may be subjected to quite a smart stroke without breaking, but if a particle of the tail is nipped off, the whole flies into fine powder with almost explosive violence.

" Mr. Peter did show us the experiment (which I had heard talked of) of the chymicall glasses, which break all to dust by breaking off a little small end; which is a great mystery to me " (Samuel Pepys, " Diary," January 13, 1662).

Sir David Brewster discovered that the fracture of these unannealed drops was accompanied by the evolution of electrical light, which appears even when they are broken under water. Mr. Bennet observed that when one of the drops was placed upon a book, the latter was electrified negatively.

References.—The articles on " Annealing," " Optics," and " Electricity " in the " Encyclopædia Britannica "; also the biography in " Penny Cycl.," Vol. XX. pp. 226–227; Le Cat, " Memoir," London, 1749–1750, or *Philos. Trans.*, XLVI. p. 175.

A.D. 1665.—Grimaldi (Francesco Maria), Italian philosopher (1618–1663), member of the Order of Jesuits and an associate of the astronomer Giovanni Battista Riccioli (at A.D. 1270) is the author of the important work " Physico mathesis de Lumine . . ." which cites the discovery of magnetism produced by the perpendicular holding of an iron bar.

References.—*Phil. Trans.* for 1665; " Engl. Cycl.," article " Biography," Vol. CXI. p. 207; Larousse, " Dict.," Vol. VIII, p. 1531. And, for Riccioli's works, see Houzeau et Lancaster, " Bibliog. Gén.," Vol. III. p. 238; " Journ. des Sçavans " pour 1665 et 1666, pp. 642–647.

A.D. 1665.—Glanvill (Joseph), an eminent English divine and philosopher, Chaplain to King Charles II and F.R.S., sometimes called " Sadducismus Triumphatus Glanvill," endorses in his " Scepsis Scientifica " (" the vanity of dogmatizing recast ")—published originally in 1661—the views advanced previously by the Jesuit Leurechon, and, after discussing the objections of Sir Thomas Browne, expresses the belief that " to confer at the distance of the

Indies by sympathetic conveyances may be as usual to future times as to us in literary correspondence."

A writer in the "Bath Chronicle" reproduced a long extract from Glanvill's work, the concluding sentence of which, he says, seems to have anticipated the electric telegraph. It is as follows: "But yet to advance another instance. That men should confer at very distant removes by an extemporary intercourse is a reputed impossibility; but yet there are some hints in natural operations that give us probability that 'tis feasible, and may be compassed without unwarrantable assistance from demoniack correspondence. That a couple of needles equally touched by the same magnet, being set in two dials exactly proportioned to each other, and circumscribed by the letters of the alphabet, may effect this 'magnale' (*i. e.* important result) hath considerable authorities to avouch it.

"The manner of it is thus represented: Let the friends that would communicate take each a dial, and, having appointed a time for their sympathetic conference, let one move his impregnate needle to any letter in the alphabet, and its affected fellow will precisely respect the same. So that, would I know what my friend would acquaint me with, 'tis but observing the letters that are pointed at by my needle, and in their order transcribing them from their sympathized index, as its motion directs; and I may be assured that my friend described the same with his, and that the words on my paper are of his inditing. Now, though there will be some ill-contrivance in a circumstance of this invention, in that the thus impregnate needles will not move to, but avert from each other (as ingenious Dr. Browne hath observed), yet this cannot prejudice the main design of this way of secret conveyance; since it is but reading counter to the magnetic informer, and noting the letter which is most distant in the Abecederian circle from that which the needle turns to, and the case is not altered.

"Now, though this desirable effect may possibly not yet answer the expectations of inquisitive experiment, yet 'tis no despicable item, that by some other such way of magnetick efficiency it may hereafter with success be attempted, when magical history shall be enlarged by riper inspections; and 'tis not unlikely but that present discoveries might be improved to the performance."

Glanvill is also the author of "Philosophical Considerations Touching Witches and Witchcraft," 1666, and of "The Sadducismus Triumphatus," 1681.

References.—"Dict. of Nat. Biog.," 1908, Vol. VII. pp. 1287-8; Larousse, "Dict.," Vol. VIII. pp. 1294–1295; "Nature," Vol. XVI. p. 269; "Histoire de la Philosophie," par Charles de Rémusat, Paris, 1878, Vol. II.

chap. xi. pp. 184–201; "The General Biog. Dict.," Alex. Chalmers, London, 1811, Vol. XVI. pp. 12–17; "Joseph Glanvill," by Ferris Greenslet, New York, 1905; "Imperial Dict. of Universal Biography," Vol. II. p. 642.

A.D. 1666.—Denys (William), hydrographer, of Dieppe, observes that the compasses placed in different parts of a vessel give different indications (Becquerel, "Magnétisme," p. 119; "Journal des Sçavans" pour 1665 et 1666, p. 538).

A.D. 1671.—Richer (T.), French philosopher, who was sent by the Paris Academy of Sciences to the island of Cayenne for the purpose of determining the amount of terrestrial refraction and for other astronomical objects, is the first to make known the electrical powers of the *gymnotus electricus.*

References.—Leithead, "Electricity," Chap. XII; Fahie, "El. Tel.," p. 171; Bertholon, "Elec. du Corps Humain," 1786, Vol. I. p. 171; *Mém. de l'Acad. des Sciences*, 1677, Art. VI; Richer, "Observations," etc., Paris, 1679; Bancroft, at A.D. 1769; "Cosmos," 1859, Vol. V. pp. 23–24.

A.D. 1671.—Rohault (Jacques), a French philosophical writer, and one of the earliest, ablest and most active propagators of the Cartesian philosophy in France, publishes at Paris the first edition of his "Traité de Physique," at Part III. chap. viii. pp. 198–236 of which he treats especially of amber and of the loadstone. The same passages can be seen at Vol. II. part iii. chap. viii. pp. 163, etc., of Rohault's "System of Natural Philosophy," published in London during the year 1723, and at the same chapter, pp. 388, etc., of "Jacobi Rohaulti Physica," Londini, 1718.

The latter is the last and best edition of the well-known classical translation, originally made in 1697, by Dr. Samuel Clarke, who was the friend of Sir Isaac Newton and chaplain to Bishop Moore, of Norwich. Through this work Clarke introduced very many critical notes exposing the fallacies of the Cartesian system. The "Physica" passed through four editions as the Cambridge University textbook before it was made to give way to the treatises of Newton.

A.D. 1672.—Sturm (John Christopher), a very able German mathematician, who was for thirty-four years professor of natural philosophy at the University of Altdorf (Franconia), and who, after vainly attempting to satisfactorily unite the Aristotelian and Cartesian doctrines finally adopted the Baconian philosophy, establishes the "Collegium Curiosum" on the plan of the celebrated Italian "Accademia del Cimento," alluded to under the A.D. 1609 date.

The society was founded for the purpose of studying, repeating and even modifying the most notable philosophical experiments of

the day, such as those made by Von Guericke, Boyle, Hooke and others, and its proceedings were published in 1676 and 1685 under the title of "Collegium Experimentale sive Curiosum, etc."

A.D. 1673.—Hevelius—Hevel—Hovel—Hövelke (Joannes), an eminent Polish astronomer, member of the English Royal Society, and a great friend more particularly of le Père M. Mersenne, of Gassendi and of Kircher, publishes during 1673 the first part of his great work "Machina Cœlestis"—dedicated to Louis XIV—the entire second part of which, issued in 1679, was destroyed by fire with the exception of seven copies. This explains its extreme scarcity. It was this work which led to the public controversy between Hevelius and Dr. Hooke who published, in London, during 1674 his "Animad. in Mach. Celest. Hevelii."

It is said that, next to John Flamsteed, Hevelius was the most accurate observer of the heavens in his day ("The Reliquary," London, Vol. XIV. pp. 149–159 and Vol. XV. pp. 34–38; "Journal des Savants" for March, June and November 1836). He had already published "De Variatione acus magneticæ" (*Opusc. Act. Erudit. Lips.*, Vol. I. p. 103), also a report of the variations of the magnetical needle during 1670, which can be found in the *Phil. Trans.*, Vol. V. for 1670, p. 2059, or in Hutton's abridgments, London, 1809, Vol. I. p. 514.

References.—Larousse, "Dict.," Vol. IX. pp. 266–267; "Biog. Gén.," Vol. XXV. pp. 285–294; Delambre, "Hist. de l'Astron. Mod.," Vol. II. pp. 434–484; Weidler, "Hist. Astron.," p. 485; "Mem. Roy. Soc.," 1739, Vol. I. p. 274.

A.D. 1675.—Boyle (Robert), Irish natural philosopher and chemist, seventh son of Richard Boyle, Earl of Cork, and one of the first members of what he calls the "Invisible" or "Philosophical" College, which has since become the Royal Society,[1] gives, in his "Philosophical Works," the result of his many experiments upon magnetism and electricity.

John Evelyn in his letter to Mr. Wotton, March 30, 1695 ("Memoirs, Diary and Correspondence," by Wm. Bray, London, p. 716), says of Boyle: "It must be confess'd that he had a marvailous sagacity in finding out many usefull and noble experiments. Never did stubborn matter come under his inquisition but he extorted a confession of all that lay in her most intimate recesses; and

[1] "The meetings, from which the Royal Society originated, commenced about the year 1645, a number of persons having then begun to assemble for the consideration of all subjects connected with experimental inquiries; all questions of theology and policy being expressly precluded" (Dr. Geo. Miller, from Harris's "Life of Charles II," Vol. I. p. 7, London, 1766).

what he discover'd he as faithfully register'd, and frankly communicated. . . ."

Prof. Tyndall remarks ("Lecture," February 4, 1875): "The tendency to physical theory showed itself in Boyle. He imagined that the electrified body threw out a glutinous or unctuous effluvium, which laid hold of small bodies, and, in its return to the source from which it emanated, carried them along with it."

A few of his many characteristic remarks and observations are, however, best given in his own words, as extracted from the "Philosophical Works" above alluded to:

"The invention of the mariner's needle, which giveth the direction, is no less benefit for navigation than the invention of the sails, which give the motion" (London, 1738, Vol. I. p. 62).

"I, with a certain body (rough diamond), not bigger than a pea, but very vigorously attractive, moved a steel needle, freely poised, about three minutes after I had left off rubbing it" (Vol. I. p. 508). Speaking elsewhere of his experiments with diamonds, he says: "But when I came to apply it (the loadstone) to one more, which look'd somewhat duller than almost any of the rest, I found that it had in it particles enough of an iron nature to make it a magnetical body and observed without surprise that not only it would suffer itself to be taken up by the strongest pole of the loadstone, but when the pole was offer'd within a convenient distance it would readily leap through the air to fasten itself to it."

"I removed a piece of amber in the sunbeams till they had made it moderately hot and then found it would attract those light bodies it would not stir before" (Vol. I. p. 400, and Vol. III. p. 52).

"Whether from such experiments one may argue that it is but, as it were, by accident that amber attracts another body, and not this the amber; and whether these ought to make us question, if *electrics may*, with so much propriety, as has been generally supposed, *be said to attract*, are doubts, that my design does not oblige me to examine" (Vol. IV. p. 350).

References.—John Evelyn's "Diary," Letter to Mr. Wotton, March 30, 1696; Libes' "Histoire Phil. du Progrès de la Physique," Paris, 1810; Boyle's "Mechanical Origine or Production of Electricity," 1675; Birch, "Life of Hon. R. Boyle," 1743–1744; Secondat's "Histoire d'Electricité" (Observations physiques), 1750, p. 141; Whewell, "Hist. of Ind. Sciences," 1859, Vol. I. pp. 395, 396. Priestley's "History of Electricity," 1775, pp. 5–8; M. Reael, "Observ. a. d. Magnectsteen," 1651, alluded to at note, p. 486, Vol. I. of Van Swinden's 1784 "Recueil," etc.; Van Swinden, Vol. II. pp. 353, 359–361; "Biblioth. Britan." (Authors), Robt. Watt, Edinburgh, 1824, Vol. I. pp. 142–3; Aikin's "G. Biography," and Martin's "Biog. Philosophica," in "General Biog. Dict.," by John Gorton, London, 1833, Vol. I; *Phil. Trans.*, Vol. VIII for 1673, p. 6101 and Hutton's abridg., Vol. II. p. 90; Boyle, London, 1673, "Essays of the . . . Effluviums" (Subtility), pp. 38–42, 52–53;

(Efficacy) pp. 18, 19, 32, 33; (Determinate Nature) pp. 21, 57; "An Essay . . . of Gems," London, 1672, pp. 108–129; Ch. W. Moulton, "Library of Literary Criticism," Vol. II. pp. 416–420; "Critical Dict. of Engl. Lit.," S. Austin Allibone, Philad., 1888, Vol. I. pp. 232–233; "Essays in Historical Chemistry," T. E. Thorpe, London, 1894, pp. 1–27; Eighth "Britannica," V. p. 259 for notes of Boerhaave, also the "Britannica" 1st Dissertation, p. 47, and 4th Dissertation p. 597; "History and Heroes of the Art of Medicine," J. Rutherfurd Russell, London, 1861, pp. 233–246.

Consult also Boyle's "New Exper. Physico-Mechanical," etc., in which the 16th Exp. is "concerning the operation of the loadstone"; Boyle's "A Continuation of New Exp.," etc., in which the 31st Exp. is "about the attractive virtue of the loadstone in an exhausted receiver," and in which are "Notes, etc., about the atmospheres of consistent bodies," etc., as well as "Observations about the exciting of the electricity of bodies," and concerning the electrical emanations and effluviums. Boyle's "Tracts Containing Some Suspicions Concerning some Occult Qualities of the Air; with an Appendix Touching Celestial Magnets," etc. His "Phil. Works," London, 1744, Vol. III. pp. 65, 67 and 70, 647, etc., give "Experiments and Notes about the Mechanical Origin or Production of Electricity."

For full accounts of the Royal Society, alluded to above, see the histories written by Thomas Sprat (1667), by Thomas Birch (1756), by Thomas Thomson (1812), and by Chas. Richard Weld (1847–1848).

A.D. 1675.—Picard (Jean), eminent astronomer, who succeeded Gassendi (A.D. 1632) as professor of astronomy at the Collège de France, is the first to observe electric light *in vacuo*. According to Tyndall ("Lessons in Electricity," p. 88) it was while carrying a barometer from the Observatory to the Porte Saint-Michel in Paris that he noticed light in the vacuous portion. Sebastien and Cassini observed it afterwards in other barometers (see Tyndall's "Lecture V." p. 91, for Priestley's description of the electric light *in vacuo*).

It was this same scientist who had already given, in his "Mesure de la Terre," 1671, Article IV, the description of the measurement of a degree of latitude made with instruments of his own manufacture.

References.—Humboldt, "Cosmos," 1859, Vol. V. pp. 23, 24; Larousse, "Dict.," Vol. XII. p. 937; "Phil. Hist. and Mem. of the Roy. Acad. at Paris," London, 1742, Vol. I. pp. 208–221.

A.D. 1675.—Newton (Sir Isaac), prominent English mathematician and natural philosopher, of whom Macaulay says that "in no other mind have the demonstrative faculty and the inductive faculty coexisted in such supreme excellence and perfect harmony," communicates to the Royal Society his discovery that excited glass will attract any light bodies even to the surface opposite to that upon which it has been rubbed. This was successfully demonstrated by the Society, January 31, 1676.

He improved the electric machine by substituting a glass globe for the globe of sulphur made use of by both Von Guericke and Boyle, the rubbers in every case being the hands of the operator.

He appears to have somewhat anticipated Franklin's great discovery, judging by the following letter he addressed, December 15, 1716, to the Rev. Dr. Law, in Suffolk:

"Dear Doctor," it begins, "He that in ye mine of knowledge deepest diggeth, hath, like every other miner ye least breathing time, and must sometimes at least come to terr; alt (terra alta) for air. In one of these respiratory intervals I now sit doune to write to you, my friend. You ask me how, with so much study, I manage to retene my health. Ah, my dear doctor, you have a better opinion of your lazy friend than he hath himself. Morpheus is my best companion; without eight or nine hours of him ye correspondent is not worth one Scavenger's peruke. My practizes did at ye first hurt my stomach, but now I eat heartily enow, as y' will see when I come down beside you. I have been much amused by ye singular *φενομενα* resulting from bringing a needle into contact with a piece of amber or resin fricated on silke clothe. Ye flame putteth me in mind of sheet lightning on a small—how very small—scale. But I shall in my epistles abjure philosophy, whereof when I come down to Sakly I'll give you enow. I begin to scrawl at five mins. from nine of ye clk, and have in writing consumed ten mins. My Lord Somerset is announced."

Æther, according to Sir Isaac Newton, is a thin subtile matter much finer and rarer than air. Sometimes, it is termed by him, a subtil spirit, as in the latter part of his "Principia," and sometimes a subtil ætherial medium, as in his "Optics." By many it is supposed to pervade all space, also the interior of solid bodies, and to be the medium of the transmission of light and heat. The æther of Descartes was his *materia subtilis* or his First Element: by which he understood a "most subtil matter very swiftly agitated, fluid, and keeps to no certain figure, but which suits itself to the figure of those bodies that are about it. His Second Element consists of small Globules; that is, bodies exactly round and very solid, which do not only, like the First Element, fill up the pores of bodies but also constitute the purest substance of the Æther and Heaven" (Blome's translation of Descartes' "Philosophy," p. 101; R. Lovett, "The Subtil Medium Prov'd"; *Phil. Mag.*, Vol. XVIII. p. 155).

During the years 1686 and 1687 Newton composed his "Principia," a work which Lagrange pronounced "la plus haute production de l'esprit humain": "the greatest work on science ever produced" (Sir Robt. Ball)., and "which will be memorable not only in the annals of one science or of one country, but which will form

an epoch in the history of the world." This was published at Halley's expense. As Brewster says (1686, Chap. XII): "It is to Halley alone that science owes this debt of gratitude. It was he who tracked Newton to his college, who drew from him his great discoveries, and who generously gave them to the world."

In the twenty-third proposition of the second book, fifth section, Newton says: "The virtue of the magnet is contracted by the interposition of an iron plate and is almost terminated at it, for bodies further off are not so much attracted by the magnet as by the iron plate." And in Book III. prop. vi. he thus expresses himself: "The magnetic attraction is not as the matter attracted; some bodies are attracted more by the magnet, others less; most bodies not at all. The power of magnetism in one and the same body may be increased and diminished, and is sometimes far stronger for the quantity of matter than the power of gravity; and in receding from the magnet decreases, not in the duplicate, but almost in the triplicate proportion of the distance, as nearly as I could judge from some rude observations."

Newton is said to have carried in his ring a magnet weighing but three grains, which could raise 746 grains, or nearly 250 times its own weight. This magnet naturally excited much admiration, but is greatly surpassed in power by that formerly belonging to Sir John Leslie, and now in the Physical Collection at Edinburgh, weighing three and one-half grains, and having a carrying power of 1560 grains.

References.—Brewster's "Life of Sir I. Newton," pp. 307, 308; "Dict. of Nat. Biog.," Vol. XL. pp. 370–393; Ch. W. Moulton, "Library of Literary Criticism," Vol. II. pp. 710–726; "Bibl. Britan." (Authors), Robt. Watt, Edinburgh, 1824, Vol. II., p. 701; Harris, "Magnetism," Vol. III. p. 11; Ninth "Britannica," Vol. XV. p. 274; Whewell, "Hist. of the Ind. Sciences," 1858, Vol. I. pp. 385–488; the interesting note at foot of p. 683 of the Fourth Dissertation in the "Encyclopædia Britannica"; "Muspratt's Chemistry," Vol. II. p. 255; the English "Chemical News" for November 1867, and January 1868, reproducing Sir David Brewster's letters to the London "Athenæum" and London "Times," likewise Dr. Crompton's paper read before the Manchester Literary and Philosophical Society in October 1866; *Phil. Trans.*, Vol. LXIV. Part I for 1774, p. 153: "Remarks of John Winthrop upon . . . Castillione's Life of Sir Isaac Newton"; Dr. Geo. Miller, "Hist. Phil. Ill.," London, 1849, Vol. III. pp. 414–415; "Newton, sa vie et ses œuvres" in "Cosmos," September 27, 1890 to December 13, 1890; "Journal des Savants" for April, May and June 1832; for April 1846, March, April, May, June, July and August 1852, October, November 1855; Houzeau et Lancaster, "Bibl. Gén.," Vol. II, 1882, pp. 213–214, 1586; "Hist. de la Philosophie," par Chas. de Rémusat, Paris, 1878, Vol. II. chap. xii. pp. 202–222.

A.D. 1676.—Haward, master of several sailing vessels, and a man of good credit (*Phil. Trans.*, Vol. XI. No. 127, p. 647, of July 18, 1676), states that "being on board of the ship Albemarle, July 24,

1641 . . . in latitude of Bermuda . . . after a terrible clap of thunder . . . it was found that the compass card was turned around, the N. and S. points having changed positions and, though Mr. Grofton brought with his finger the flower-de-lys to point directly N., it would immediately, as soon as at liberty, return to this new unusual posture, and upon examination he found every compass (three) in the ship of the same humour; which . . . he could impute to nothing else but the operation of the lightning or thunder mentioned." The above is also alluded to at p. 33 of Vol. III. of Boyle's "Phil. Works," London, 1738, with this addition: "One of the compasses, pointing West, was brought to New England, where, the glass being broke and the air gaining entrance, it lost its virtue. But one of the others is in that country possess'd by Mr. Encrease Mather, the North point of the needle remaining South to this day."

A.D. 1677.—At p. 14 of an exceedingly curious publication entitled "A Rich Cabinet with a Variety of Inventions," etc., written by J. W. (*i. e.* John White, of London), who calls himself "a lover of artificial conclusions," will be found an article on "Divers rare, conceited motions performed by a magnet or loadstone."

A.D. 1678.—Redi (Francesco), well-known Italian scientist, physician to the Grand Duke Ferdinand II, publishes his "Experimenta circa res diversas Naturales," wherein he is first to communicate the fact that the shock of the *raia torpedo* can be transmitted to the fisherman through the line and rod connecting him with the fish.

References.—Leithead, "Electricity," Chap. XII; the Firenze. 1671 ed. of Redi's "Esperienze," etc., pp. 47–54; *Phil. Trans.* for 1673, Vol. VIII. p. 6003; *Sci. Am. Supp.*, No. 457, pp. 7300–7302; Matteucci, "Recherches," 1837 and 1867; Eschinardi (F. della Compagnia di Gesū), "Lettera al S. Francesco Redi," Roma, 1681, wherein are detailed many curious experiments, including some treating of the magnetic needle by which agency are foretold sudden attacks of earthquakes, etc. etc.

A.D. 1679.—Maxwell (William)—Guillelmo Maxvello—native of Scotland, author of "Medicina Magnetica," offers to prove to various medical faculties that, with certain magnetic means at his disposal, he could cure any of the diseases abandoned by them as incurable (Blavatsky, "Isis," Vol. I. p. 215).

Reference.—J. H. Van Swinden, "Recueil de Mémoires," etc., La Haye, 1784, Vol. II. p. 367.

A.D. 1683.—Arrais (Edoardo Madeira), who had been physician to—João—John IV, the first Portuguese king of the house of

Braganza, is the author of this much-delayed edition of a book entitled "Arbor Vitæ, or a physical account of the Tree of Life in the Garden of Eden." It treats of occult qualities under the headings of "Doubts," of which latter there are eight separate ones which constitute as many different chapters, from which the following extracts will prove interesting:

"Doubt" 5, p. 45. "Doth not the fish called *Torpedo* render the fishes that swim over it immovable, and stupefy the fisher's arm with its virtue diffused along his spear?"

"Doubt" 5, p. 46. " . . . as also there are divers sorts of fishes that bring numness, as our *Torpedo* doth."

"Doubt" 5, p. 49. "And those that travail the coasts of Brasile make mention of another fish, which causeth numness as our *Torpedo* doth: whence it becomes sufficiently manifest that there are many kinds of *Torpedoes* to be found. But this kind lives especially in the river Itapecuro, in the country of the Maragnani, and it is called *Perache*, or, as Gaspar Barlæus observed, *Puraquam*, among those Barbarians. In shape and greatness it resembles a kind of lamprey (or Muræna); they use to kill it by striking it with staves; but the arm of him that strikes and then his whole body is stupefied, and shakes presently. Of which thing, Frier Christopher Severineus, Bishop elect of Angola is my ocular witness. . . ."

"Doubt" 7, p. 93. "For it is evident from experience that iron is so indisposed by some qualities that it cannot be moved by the magnet. That fishes swimming over the *Torpedo*, enclosed in the mud or sand for the purpose, when they come to the places whereto the virtue of the *Torpedo* is extended can stir no further; by which art she catches and eats them, as Aristotle relates (6 'de Hist. Animal.,' cap. 10; and 9 'de Hist.,' cap. 37)."

"Doubt" 7, p. 94. "For if amber be dulled by moisture, its virtue cannot produce motion in straws. If the virtue of the *Torpedo* reach the fishes swimming over her, or the fisher's arm their motive power cannot produce motion."

"Doubt" 7, p. 96. "And for this cause, the virtue of the magnet can produce motion in iron, not in other bodies, because it finds in it Dispositions necessary on the part of the agent which, being present, it can operate; not in other things. And, for the same reason, amber moves straws, not iron nor stones."

The preface to the "Arbor Vitæ . . ." is written by Richard Browne, M.L. Coll. Med., London, who translated out of Latin "The

Cure of Old Age," by Roger Bacon, wherein he gives quite a good account of the latter's life and writings, and from which we extract but one passage likely here to be of some little interest, viz. at p. 155, regarding the component parts of a medicine : " By Amber here our author intends Amber Gryse (a bituminous body found floating on the sea) : For he calls it Ambra and not Succinum (which is solid Amber). Besides, Succinum was never reckoned a spice as Amber is here. And though both Ambra and Succinum be great restorers of the animal spirits, yet the former is more efficacious."

The " Biographie Générale," Vol. III. p. 348, says that Duarte Madeyra Arraess, who died at Lisbon in 1652, was the author also of " Apologia," 1638, of " Methodo," 1642, and of " Novæ Philosophiæ," 1650.

A.D. 1683.—Halley (Edmund), LL.D., who became English astronomer royal, makes known his theory of four magnetic poles and of the periodical movement of the magnetic line without declination. He states that the earth's magnetism is caused by four poles of attraction, two of them being in each hemisphere near each pole of the earth. By the word *pole* he means a point where the total magnetic force is a maximum, or, as he himself styles it, " a point of greatest attraction " (Walker, " Magnetism," p. 317, etc.).

One of the magnetic poles he places near the meridian of Land's End, not above 7 degrees from the North Pole, the other being about 15 degrees from the North Pole in the meridian of California, while the two south magnetic poles are placed respectively about 16 and about 20 degrees from the South Pole of the earth, and 95 degrees west, 120 degrees east of London.

In order to test Halley's theory, the English Government permitted him to make three voyages in the Atlantic Ocean (1698, 1699, 1702), in vessels of which he had the command as post-captain. Humboldt states that these were the first expeditions equipped by any government for the establishment of a great scientific object—that of observing one of the elements of terrestrial force on which the safety of navigators is especially dependent.

The result of these voyages was the construction of the first accurate Magnetic Chart, whereon the points at which navigators have found an equal amount of variation were connected together by curved lines. This was the model of all charts of a similar nature since constructed. Halley remarked upon its completion : " The nice determination of the variation, and several other particulars in the magnetic system, is reserved for a remote posterity. All that we can hope to do is to leave behind us observations that may be

confided in, and to propose hypotheses which after-ages may examine, amend or refute."

See copy of his chart in Vol. I. No. I of "Terrestrial Magnetism," also in Musschenbroek's "Essais de Physique," or, preferably, in Bouguer's "Traité de Navigation," where the lines for 1700 are in red ink, while those for 1744 are traced in black, thus readily indicating the changes in the declination.

References.—Cavallo, "Magnetism," and "Nat. or Exp. Phil.," Vol. II. p. 273; Lloyd, "Treatise on Magnetism," 1874, p. 102; *Sci. Am. Suppl.*, No. 224, pp. 3570, 3571; Whewell, "Hist. of the Inductive Sciences," 1859, Vol. I. pp. 396–8, 435–7, 450, 451, 480, 481, and Vol. II. p. 225; Giambattista Scarella, "De Magnete," 1759, Vol. II; also G. Casali, "Sopra la Grandine," etc., 1767; "The Phil. Hist. and Mem. of the Roy. Ac. of Sciences at Paris," London, 1742, Vol. I. p. 245; Vol. II. pp. 240–244, 270, 349; "Magnetic Results of Halley's Expedition (1698–1700)" in "Terrestrial Magnetism," September 1913, pp. 113–132; Houzeau et Lancaster, "Bibl. Gén.," Vol. II. pp. 156–7; Dr. G. Hellmann "Neudrucke von schriften," Nos. 4 and 8; Humboldt, "Cosmos," 1859, Vol. V. pp. 59–60; John Wallis's letters to Halley, London (*Phil. Trans.* for 1702–1703), p. 106; *Phil. Trans.* for 1667, 1683, 1692; "Memoirs of the Roy. Soc.," 1739, Vol. II. p. 195; "A Bibliography of Dr. Edmund Halley," by Alex. J. Rudolph, in the "Bulletin of Bibliography" for July 1905; "Old and New Astronomy," by Richard A. Proctor, 1892, pp. 37–38; *Phil. Trans.* Vol. XIII for 1683, No. 148, p. 208; Vol. XVII. p. 563; Vol. XXIII. p. 1106; Vol. XXIX. p. 165; Vol. XLII. p. 155; Vol. XLVIII. p. 239, also the following abridgments: Hutton, Vol. II. p. 624; Vol. VI, pp. 99, 112; J. Lowthorp, Vol. II. p. 285; Reid and Gray, Vol. VI. p. 177; Eames and Martyn, Vol. VI. pp. 28, 286; Baddam, 1745, Vol. II. pp. 195–202; Vol. III. pp. 25–32.

Aurora Borealis, or Northern Polar Light

Dr. Halley was the first to give (*Phil. Trans.*, No. 347) a distinct history of this phenomenon, which has certainly an electric as well as magnetic origin, and to which Gassendi originally gave the name it now bears, as has been stated at A.D. 1632.

According to Dr. Lardner ("Lectures," Vol. I. p. 137), Prof. Eberhart, of Halle, and Paul Frisi, of Pisa, first proposed an explanation of the aurora founded upon the following: 1. Electricity transmitted through rarefied air exhibits a luminous appearance, precisely similar to that of the aurora borealis. 2. The strata of atmospheric air become rarefied as their altitude above the surface of the earth is increased, a theory which has since been countenanced by many scientists. It has been observed, notably by Dalton, of Manchester, that the primitive beams of the aurora are constantly in a direction parallel to that of the dipping needle, and that the latter appears most affected when the aurora is the brightest. Arago noticed that the changes of inclination amounted, upon one occasion to 7′ or 8′. The discovery that the magnetic needle was

agitated during the presence of an aurora has been ascribed to Wargentin (*Am. Journal Sc.*, Vol. XXX. p. 227), though it is claimed by the friends of Olav Hiörter (see A.D. 1740), that it was independently ascertained by the latter during the year 1741.

The well-known Swiss chemist Auguste Arthur De la Rive has made many important observations upon the electric character of the aurora, the experiments carried on by him in the mountains of Finland being thus described: "We surrounded the peak of a mountain with copper wire, pointed at intervals with tin nibs. We next charged the wire with electricity, and nearly every night during our stay produced a yellowish white light on the tin points, in which the spectroscope analysis revealed the greenish yellow rays so characteristic of the aurora borealis. On the peak of Pietarintumturi we were especially successful, an auroral ray making its appearance directly over and about 150 yards above the copper coil."

A complete list of all auroras appearing prior to 1754 is to be found in Jean Jacques d'Ortons de Mairan's, Paris, 1731, "Traité Physique de l'Aurore Boréale," and a catalogue of auroræ observed, 1800–1877, has been made up by M. Zenger (*Sci. Am. Supp.*, p. 10915). One of the most interesting displays is known as the *purple aurora*, alluded to in the Annals of Clan-mac-noise as having appeared A.D. 688 (Biot "Note sur la direction," etc., *Comptes Rendus*, Tome XIX for 1844, p. 822). Between September 19, 1838, and April 8, 1839, Lottin, Bravais, Lilliehöök and Siljeström observed 160 auroras at Bossekop (69° 58′ N. lat.) in Finmark and at Jupvig (70° 6′ N. lat.); they were most frequent during the period the sun remained below the horizon, that is, from November 17 to January 25. During this night of 70 times 24 hours there were 64 auroras visible (*Comptes Rendus*, Tome X. p. 289; Martin, "Météorologie," 1843, p. 453; Argelander, in the "Vorträgen geh. in der Königsberg Gesellschaft," Bd. I. s. 259).

A Finnish physicist, named S. Lenström, who had been attached to the Nordenskjold Polar Expedition of 1868, visited Lapland in 1871, and, after a series of important observations, constructed an apparatus that permitted him to "artificially reproduce the light of the aurora." The intensity of this light is so great at times that Lowenörn perceived the coruscations in bright sunshine on the 29th of January, 1786, and Parry saw the aurora throughout the day during the voyage of 1821–1823.

The height of the aurora has been variously estimated, but it is seldom found to be less than forty-five miles above the surface of the earth. Father Boscovich estimated at 825 miles the height of the one observed by the Marquis of Poleni on the 16th of December,

1737. The extent of the aurora, according to Dalton, has been known to cover an area of 7000 or 8000 square miles.

References.—"Mem. de Turin," An. 1784–5, Vol. I. part ii. pp. 328, 338; Young, "Lectures," Vol. I. pp. 687, 716; Herschel, "Prelim. Discourse," pp. 93, 329, 330; *Phil. Trans.*, 1753, p. 350; Müller's "Kosmischen Physik"; Noad, "Manual," pp. 225–237; also all the references at pp. 187–196, Vol. I of Humboldt's "Cosmos," Bohn, London, 1849, as well as in Ronalds' "Catalogue," pp. 23–24; Mairan, at Vol. X. p. 961, "Dict. Univ.," and Vol. XXVI. p. 161, of the "Biog. Universelle"; *Trans. Cambridge Phil. Soc.*, Vol. I; "Isis Unveiled," Vol. I. pp. 417, 418.

See likewise the "Pharsalia" of Marcus Annæus Lucanus, translated by J. Krais, I. pp. 518–527; Plutarchus, "De facie in orbe lunæ," cap. 26; the "Annals" of Caius Cornelius Tacitus, Germania, XLV. 1st ed., Venice, 1470; "Das Polarlicht," H. Fritz, Leipzig, 1881, pp. 4–6, 332; Mairan's "Traité Physique," etc., 1731, pp. 179–181; Grégoire du Tour, *Lumière Electrique*, 1882, Vol. VII. p. 389; Elias Loomis, "The Aurora Borealis," etc., p. 220 of the Reports of Smiths. Inst., 1865; A. M. Mayer, "Observations," etc., *Amer. Jour. of Sc.*, February 1871; "A copy of the Catalogue of Aurorae Boreales observed in Norway from the earliest times to June 1878" ("Nature," December 4, 1902, p. 112); "La cause de l'aurore boréale," Claudius Arrhenius, in the *Revue Générale des Sciences* for January 30, 1902, pp. 65–76; "Les Années Météores," in "Le Cosmos," Paris, May 25, 1889, etc.; "Terrestrial Magnetism," March 1898, p. 7 for Chronological Summary of Authors *re* Aurora; Rev. Jas. Farquharson in "Abstracts of Sc. Papers Roy. Soc.," Vol. II. p. 391; Wm. Dobbie, *Phil. Mag.*, Vol. LXI for 1823, p. 252; W. Derham, for description of Auroras (in *Phil. Trans.* for 1728, p. 453); see, for Boscovitch, "Journal des Savants," February 1864; "Journal des Savants," for August 1820; C. H. Wilkinson, "Elements," 1804; Vol. II. p. 279 and note; Calogera's "Raccolta," XVII. 47, *Proc. of the Royal Soc. of Edinburgh* for the observations of J. A. Brown and others on the aurora; F. C. Meyer, De luce boreali, 1726; Poggendorff, I. 135; Sturgeon, "Sc. Res." 4th Sec. p. 489; *Phil. Trans.*, Vol. XXXVIII. p. 243; Vol. XLVI. p. 499; F. Zöllner's paper in "L. E. and D. Philos. Mag.," for May and July, 1872; C. A. Young, *Amer. Jour. of Sc.*, Vol. III., 3rd s., p. 69; Baron Karl Von Reichenbach's "Physico-Physiological Researches," trans. of Dr. John Ashburner, London, 1851, pp. 5–36, also pp. 445, etc., of the translation of Dr. W. Gregory, London, 1850; J. H. Van Swinden, "Recueil de Mémoires," etc., La Haye, 1784, Vol. III. p. 187, etc.; J. E. B. Wiedeburg, "Beobachtungen und Muth.," etc., 1771; G. W. Krafft, "Observ. Meteor," etc., in *Novi Com. Acad. Petrop.*, Vol. V. p. 400; Giuseppe Toaldo, "Descrizione," etc., in *Saggj . . . Accad. di Padova*, Vol. I. p. 178; Louis Cotte, "Table of Auroræ, Observed . . . 1768–1779," Paris, 1783; *Journal de Physique* for 1775; *Recueil de Mem. de l'Acad. des Sciences* for 1769; A. S. Conti, "Rifflessioni sull' Aurora Boreale." [1]

For *Auguste Arthur De la Rive*, consult "Bibl. Britan.," Vol. XVI, N.S., 1821, p. 201, likewise the "Annales de Chimie et de Physique," *Phil. Mag.*, *Phil. Trans.*, *Comptes Rendus*, more especially, as well as the "Bibl. Univ." and the "Mem. de la Soc. de Genève," at which latter place he was born in 1801.

For *Jean Jacques d'Ortons de Mairan*, consult "Mém. de Paris" for the years 1726, 1731–1734, 1747, 1751, also abridgments of the *Phil.*

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[1] In the entry at p. 223, Part I of Libri's "Catal." for 1861 it is said that, in the first volume of the works of A. S. Conti, who was the intimate friend of Sir Isaac Newton, we find for the first time mention of the fact that the aurora is supposed to be an electrical phenomenon.

Trans. by Hutton, Vol. VII. p. 637, and by Baddam, 1745 ed., Vol. IX. pp. 490–497.

For *W. Derham* (1657–1735) consult also "Nouv. Biog. Gen." (Hœfer), Vol. XIII. p. 712; the *Phil. Trans.* unabridged, Vol. XXIV. for 1704–1705, pp. 2136–2138; Vol. XXXVI. pp. 137, 204, also the following abridgments: Hutton, Vol. V. pp. 258–263; Hy. Jones, Vol. IV. part ii. pp. 290–291; Baddam, Vol. IV. pp. 473–478. In the last-named volume is thus given an account of Mr. Derham's experiments: "He shows (*Phil. Trans.*, No. 303, p. 2136) that, having consulted what others had writ of magnets, he finds in Grimaldi's *De Lumine et colore* that both he and M. De la Hire (*Phil. Trans.*, No. 188) had hit upon the same discovery before him." Mr. Derham also alludes, more particularly, to the observations of Ridley, Barlow and Dr. Gilbert.

For *Claudius—Claes—Arrhenius* (1627–1694) Swedish scientist, professor at the Upsal University, consult "La Grande Encycl.," Vol. III. p. 1107; "Dict. Biog. Suédois," Vol. XXII. pp. 385–389.

For *John Wallis*, the celebrated English mathematician (1616–1703), in addition to the above-named *Phil. Trans.*, Vol. XXIII for 1702–1703, p. 1106, consult *Phil. Trans.*, Vol. XII for 1677, No. 135, pp. 863–866 (meteors), also the abridged editions as follows: Hutton, Vol. IV. pp. 196, 639, 655; Hy. Jones, Vol. IV. part ii. p. 286; Baddam, London, 1739, Vol. III. p. 228 and Vol. IV. pp. 100–104 (mariner's compass); "Nouv. Biog. Gen." (Hœfer), Vol. XLVI. p. 530.

Aurora Australis, or Southern Polar Light

The earliest account of this phenomenon was given by Don Antonio de Ulloa, as will be seen under date A.D. 1735–1746.

References.—W. L. Krafft, "Observation," etc., in *Acta Acad. Petropol.* for 1778, Part I. Hist., p. 45; *Phil. Trans.*, XLI. pp. 840, 843; XLVI. pp. 319, 345; Chr. Hansteen, "On the Polar Lights," London, 1827.

Zodiacal Light

This phenomenon, from its occasional faint resemblance to and association with the auroras, would seem to deserve mention here, though none of the conjectures formed, more particularly by Cassini, Euler, Mairan, Kepler, Laplace, Fatio de Duiller, Schubert, Poisson, Olmsted, Biot, Herschel, Delambre, Olbers or Sir Wm. Thomson attribute to it any electric or magnetic origin.

In the *Report of the Proceedings of the Reale Istituto Lombardo*, 1876, however, appears the account of many observations confirmed by M. Serpieri which "demand absolutely" the conclusion that the zodiacal light "is an electrical aurora preceding and following the sun round the earth."

Angstrom asserted that he observed the auroral line in the spectrum of the zodiacal light, and Lewis saw the latter during the aurora of May 2, 1877. Humboldt, who observed it ("Cosmos," 1849, Vol. I. p. 126) in the Andes at an elevation of 13,000 to 15,000 feet, as well as on "the boundless grassy plains, the Llanos of Venezuela, and on the seashore, beneath the ever-clear sky of

Cumana," believes it to be caused by "a very compressed annulus of nebulous matter, revolving freely in space between the orbits of Venus and Mars." In this connection he refers to Arago in the *Annuaire* for 1832, p. 246, and to a letter published in *Comptes Rendus*, XVI, 1843, p. 687, from which the following is extracted: "Several physical facts appear to indicate that, in a mechanical separation of matter into its smallest particles, if the mass be very small in relation to the surface, the electrical tension may increase sufficiently for the production of light and heat."

In Chambers' "Descript. Astronomy," p. 257, the historian Nicephorus is credited with first calling attention to the existence of this phenomenon, to which Giovanni Domenico Cassini gave the name of Zodiacal Light, after determining its relations in space during the year 1683 (*Mém. de l'Académie*, 1730, Tome VIII. pp. 188 and 276), but to Childrey belongs the credit of having given to Europe the first explicit description of this phenomenon at p. 183 of his 1661 "Britannia Baconica."

References.—Sturgeon's *Annals*, etc., Vol. II. pp. 140–142; Prof. C. W. Prichett's paper in *Sci. Am. Supp.*, No. 126, p. 2008, and the conclusions reached by Herr Gronemann (*Archives Néerlandaises*) in *Sci. Am. Supp.*, No. 327, p. 5221; Whewell, "Hist. of the Ind. Sciences," 1859, Vol. I. p. 531, and Vol. II. p. 609; Tyndall, "Heat as a Mode of Motion," 1873, pp. 57, 58, 497, 498; J. F. J. Schmidt, "Das Zodiacallicht," Braunschweig, 1856; the very interesting abstract given in "The Journal of the Brit. Assoc.," Vol. XII. No. 5, of paper read by Rev. J. T. W. Claridge, F.R.S., Jan. 9, 1902; Houzeau et Lancaster, "Bibl. Générale," Vol. II. 1882, pp. 763–771; "Pr. Roy. Soc. of Edin.," XX. pt. 3; C. Wilkes, "Theory of Zod. Light," Philad., 1857; *Phil. Trans.*, Vol. XXXVIII. p. 249; "Cosmos," 1849, Vol. I. pp. 126–134; "Anc. Mém. de Paris," I, VIII and X; J. J. de Mairan, Paris, 1733; "U. S. Japan Expedition," Vol. III, Washington, 1856.

A.D. 1684.—Hooke (Dr. Robert), English natural philosopher (1635–1703), who, in 1677, had succeeded Oldenburg as Secretary to the Royal Society, gives the earliest well-defined plan of telegraphic transmission, in a paper addressed to the Royal Society "showing a way how to communicate one's mind at great distances . . . 40, 100, 120, etc., miles . . . in as short a time almost as a man could write what he would have sent." His apparatus consisted of an elevated framework supporting an open screen, behind which were suspended as many wooden devices, or symbols, such as circles, squares, triangles, etc., as there were letters in the alphabet. In the daytime these devices were drawn up by a rope behind the screen and made visible in the open space, while during the night use was made of torches, lanterns or lights.

Hooke also showed, in 1684, that iron and steel rods can be permanently magnetized by strongly heating them and by rapidly

cooling them in the magnetic meridian ("Enc. Brit.," 1857, Vol. XIV. p. 3).

But, what is still more singular, he had, even previous to the above-named date (*i. e.* in 1667), alluded to the possibility of telephoning, that is, communicating sound through a wire. He thus expresses himself: "And as glasses have highly promoted our seeing, so it is not improbable that there may be found many mechanical inventions to improve our other senses—of hearing, smelling, tasting, touching. . . . 'Tis not impossible to hear a whisper a furlong's distance, it having been already done; and perhaps the nature of the thing would not make it more impossible though that furlong should be ten times multiplied. And though some famous authors have affirmed it impossible to hear through the thinnest plates of Muscovy glass, I know a way by which it is easy to hear one speak through a wall a yard thick. It has not been examined how far acoustics may be improved, nor what other ways there may be of quickening our hearing, or conveying sound through other bodies than the air, for that is not the only medium. I can assure the reader that I have, by the help of a distended wire, propagated the sound to a very considerable distance in an instant, or with as seemingly quick a motion as that of light, at least, incomparably swifter than that which at the same time was propagated through the air; and this not only in a straight line, or direct, but in one bended in many angles."

References.—Hooke's entire paper in Derham's "Phil. Exp. and Obs." for 1726, pp. 142–150; *Phil. Trans.* for 1684; for his observations on atmospheric electricity consult Houzeau et Lancaster, "Bibl. Gén.," Vol. II. p. 166; "Journal des Savants" for April 1846; "The Posthumous Works of Robert Hooke," London, 1705, p. 424; "Revue Scientifique," Mars 15, 1902, p. 351; for a complete list of all his works, consult Ward's "Lives of the Gresham Professors"; for description of his telegraph and reference to Amontons, etc., see *Phil. Mag.*, Vol. I. pp. 312–316.

A.D. 1684.—Sturmy's "Mariner's Magazine" for this year, of which a copy can be seen in the library of the British Museum, contains an account of the deviation of the compass and its tendency to give misleading directions on account of local attraction.

References.—*Chambers' Journal*, Vol. III. No. 60 for Feb. 24, 1855, p. 132, and Vol. XII. No. 300 for Oct. 1, 1859, p. 246; Capt. Sam. Sturmy's "Magn. Virtues and Tides," in *Phil. Trans.*, No. 57, p. 726, or "Memoirs of the Roy. Soc.," Vol. I. p. 134; *Phil. Trans.*, abridgments: by Hutton, Vol. II. p. 560, and by Lowthorp, Vol. II. p. 609; "Journal des Sçavans" for 1683, Vol. XI. pp. 267–293.

A.D. 1684.—In the "Essayes of Natural Experiments made in the Accademia del Cimento" (Englished by Richard Waller), London, 1684, by direction of the Royal Society, there are given,

respectively at pp. 53, 123 and 128–132, accounts of the operation of the magnet *in vacuo*, details of several magnetical experiments and experiments touching amber as well as other electrical bodies.

A.D. 1686.—Maimbourg (Louis), French historian, relates this instance of the employment of the magnet at Chap VI of the Rev. W. Webster's translation of his " Histoire de l'Arianisme " : " Whilst Valens (the Roman emperor) was at Antioch . . . several pagans of distinction, with the philosophers . . . not being able to bear that the empire should continue in the hands of the Christians, consulted privately the demons . . . in order to know the destiny of the emperor and who should be his successor. . . . For this purpose they made a three-footed stool . . . upon which, having laid a basin of divers metals, they placed the twenty-four letters of the alphabet around it; then one of these philosophers, who was a magician . . . holding in one hand vervain and in the other a ring which hung at the end of a small thread, pronounced . . . conjurations . . . at which the three-footed stool turning around and the ring moving of itself, and turning from one side to the other over the letters, it caused them to fall upon the table . . . which foretold them . . . that the Furies were waiting for the emperor at Mimas; . . . after which the enchanted ring, turning about again over the letters in order to express the name of him who should succeed the emperor, formed first of all these capital letters, T H E O. After adding a D, to form T H E O D, the ring stopped, and was not seen to move any more, at which one of the assistants cried out . . . 'Theodorus is the person whom the gods appoint for our emperor ' " (" History of Christianity," by the Rev. Henry Hart Milman, London, 1840, Vol. III. p. 120).

Maimbourg's biography is given at p. 58, Vol. IV. of the " English Encyclopædia."

A.D. 1692.—Dr. Le Lorrain de Vallemont relates, in " Description de l'Aimant," etc., which he published at Paris, that, after a very severe wind and rain storm during the month of October 1690, the new steeple of the Church of Notre Dame de Chartres was found to be so seriously injured as to necessitate demolition. It was then observed that the iron cross was covered with a heavy coating of rust, which latter proved to be so highly magnetic that a special report upon it was made in the " Journal des Sçavans " by M. de la Hire, December 3, 1691, at the request of Giovanni Dom. Cassini, and of other members of the French Royal Academy.

References.—" Journal des Sçavans," Vols. XX, 1692, pp. 357–364 and Vol. XXXV, 1707, pp. 493–494 for additional accounts of the

Church of N. Dame de Chartres by M. de la Hire and M. de Vallemont, and for a review of M. de Vallemont's work, of which latter pp. 4, 30, 66, 74, 89 to 90 merit special attention.

A.D. 1693.—Gregory (David), an eminent mathematician, who, in 1691, had been made Savilian Professor of Astronomy in Oxford mainly through the influence of Newton and Flamsteed, communicates the result of his observations on the laws of magnetic action.

References.—Noad, "Manual of Electricity," 1859, p. 525, *Phil. Trans.*, Vols. XVIII–XXV; "Biog. Générale," Vol. XXI. p. 902; Ninth "Britannica," Vol. XI. p. 182; J. J. Fahie, "A History of El. Tel. to the year 1837," London, 1884, p. 24.

A.D. 1693.—In the first volume (Letter IV. pp. 25–28) of the "Memoirs for the Ingenious . . ." by J. de la Crosse, are given accounts of several "New experiments on the loadstone; of a needle touch'd with it, and plac'd directly over the needle of a compass; of two Mariner's Needles hang'd freely over one another, at several distances; of a touch'd steel-ring. Reasons of these experiments. The earth magnetical."

In explanation of all this, M. de la Hire supposes "that the mass of the earth is a great loadstone, which directs the poles of the same name in all the loadstones and touch'd needles, towards the same place of the earth; so that the two hang'd needles do but remove from this natural position by the particular force they have of driving away each other's poles of the same name; which force, in a certain degree, is not sufficient to overcome the power of the great loadstone of the earth."

An account of M. P. de la Hire's "new sort of a magnetical compass" had already appeared in the *Phil. Trans.* for 1686–1687, Vol. XVI. No. 188, p. 344.

References.—For De la Hire, the following abridgments of the *Phil. Trans.:* Lowthorp, London, 1722, Vol. II. pp. 620–622; Baddam, London, 1739, Vol. IV. pp. 473–478; Hutton, London, 1809, Vol. III. p. 381; also "The Phil. Hist. and Mem. of the Roy. Acad. at Paris," by Martyn and Chambers, London, 1742, Vol. II. pp. 273–277; Vol. V. pp. 272–282 and the "Table Alphab. . . . Acad. Royale," by M. Godin, Paris, Vol. II. p. 16 and Vol. X. pp. 164 and 734.

A.D. 1696.—Zahn (F. Joannes), prebendary of the Prémontrés Order at Celle near Wurtzburg and provost of the convent of Niederzell, celebrated for his philosophical and mathematical studies, publishes his highly valued "Specula physico-mathematico-historica-notabilium ac mirabilium sciendorum . . ." throughout the three folio volumes of which he treats extensively of the wonders of the entire universe.

In his tabulated list of the origin and properties of all the different known gems and stones (Vol. II. chap. vii. p. 55), he states

that the loadstone, first discovered at Magnesia in Lydia (Caria—on the Mæander) is heavy, very well shaped, and of a dark colour verging upon blue. The marvellous properties of gems and stones are detailed at pp. 59–73 of the same volume, the fifth paragraph of Chap. VIII treating of the loadstone's many virtues and admirable qualities, as exemplified in the writings of Guilielmus Gilbertus, Nicolaus Zucchius, Nicolaus Cabæus, Athanasius Kircherus, Eusebius Nierembergius, Laurentius Forerus, Hieronymus Dandinus, Jacobus Grandamicus, Ludovicus Alcazar, Claudius Franciscus Milliet de Chales, as well as of many others.

References.—Michaud, "Biog. Univ.," Vol. XLV. p. 340; Dr. John Thomas, "Universal Pron. Dict.," 1886, p. 2514; Brunet, "Manuel du Libraire," Vol. V. p. 1519.

A.D. 1700.—Bernoulli (John I), son of Nicolas, the founder of the celebrated family of that name, improves upon Picard's discovery of the electrical appearance of the barometer, made A.D. 1675, by devising a mercurial phosphorus or mercury shining *in vacuo* ("Diss. Physica de Mercurio Lucente," etc., Basel, 1719). This procured the favourable notice of King Frederick I, of Prussia, who rewarded him with a medal. John Bernoulli I (1667–1748) was a member of nearly every learned society of Europe and "one of the first mathematicians of a mathematical age." His exceedingly valuable memoirs, found in all the scientific transactions of the day, were first collected in their entirety during the year 1742, by Cramer, Professor of Mathematics, and published at Lausanne and Geneva.

"Is it not surprising," remarks Prof. Robison, in his able article on "Dynamics" (Eighth "Britannica," Vol. VIII. p. 363), "that, twenty-five years after the publication of Newton's 'Principia,' a mathematician on the Continent should publish a solution in the Memoirs of the French Academy, and boast that he had given the first demonstration of it? Yet, John Bernoulli did this in 1710. Is it not more remarkable that this should be precisely the solution given by Newton, beginning from the same theorem, the 40th I., Prin., following Newton in every step and using the same subsidiary lines? Yet, so it is." This was five years after he had accepted (1705) the chair of mathematics made vacant by the death of his brother, James I.

Bernoulli Family

The Bernoulli family is as well known in the history of mathematics, by the distinguished services of eight of its members, as is

the Cassini family through the successes achieved by four of its representatives in the development of astronomical studies.

Daniel Bernoulli (1700–1782), second son of John I, constructed a dipping needle, which is described on p. 85 of the Eighth "Britannica," Vol. XIV, and with which he observed the dip to diminish half a degree during an earthquake in the year 1767. Before Daniel was twenty-four years old he had declined the Presidency of the Academy of Sciences at Genoa, and, at the age of twenty-five, was appointed Professor of Mathematics at St. Petersburg.

John Bernoulli II (1710–1790), youngest of the three sons of John I, gained three prizes from the French Academy of Sciences for Memoirs on the Capstan, on the Propagation of Light and on the Magnet.

John Bernoulli III (1744–1807), grandson of John I, took the degree of Doctor of Philosophy at the age of thirteen, and, when nineteen years old, was appointed Astronomer Royal of Berlin. He published several volumes of travels, in one of which he relates (A. L. Ternant, "Le Télégraphe," 1881, p. 32) that he saw, in the last-named city, an instrument constructed of five bells, with which all letters of the alphabet could be expressed.

James Bernoulli I (1654–1705), brother of John I, while at London, was introduced into the philosophical meetings of Boyle, Hooke, Edward Stillingfleet and other learned and scientific men. He opened, in 1682, the *Collegium Experimentale Physico-Mechanicum* for public instruction, but his lasting fame dates from the year 1684, when the great Von Leibnitz published his treatise "De Gravitate Ætheris." Three years later, in 1687, James occupied the mathematical chair of the University of Basel, made vacant by the death of the learned Megerlin.

References.—Whewell, "Hist. of the Inductive Sciences," 1859, Vol. I. pp. 358–366, 375–380, 393, 430, and Vol. II. pp. 32–39, 42; "Hist. de l'Acad. Royale des Sciences," 1700–1707; Edin. "Encycl.," 1813, Vol. III. pp. 464–470; "Med. Library and Historical Journal," New York, 1903, Vol. I. pp. 270–277.

For Bernoulli family see "Histoire des Sc. Math. et Phys.," Maxim. Marie, Paris, 1888, Vols. VII–XI; "Geschichte der Mathemathik," Moritz Canton, Leipzig, 1898, Vol. III. pp. 207–261; "Histoire Générale des Mathématiques," Chas. Bossut, Paris, 1810, Vol. II. s. 2, as at table, p. 512. See the family tree in "Eng. Cycl.," Vol. VI. p. 972, and all the Bernoullis at p. 84 of Vol. II, Houzeau et Lancaster's "Bibl. Gén.," 1882.

A.D. 1700.—Morgagni (Giovanni Battista), while practising medicine at Bologna and at Venice, uses the magnet to remove particles of iron which had accidentally fallen into the eyes, exactly in the same manner as Kirkringius and Fabricius Hildanus had done before him.

References.—Maunder's "Biog. Treasury"; also Beckmann's "History of Inventions," Vol. I. p. 44, and biography in Larousse, Vol. XI, as well as in Vol. XVI of the Ninth "Britannica."

A.D. 1700.—Duverney (Joseph Guichard), an eminent French anatomist, knew at this date that the limbs of a frog are convulsed by the electric current (as shown in the "Histoire de l'Académie des Sciences," 1700, p. 40, and 1742, vol. I. p. 187), and the Italian physician L. Marco Antonio Caldani, assistant to Morgagni, alludes to the "revival of frogs by electrical discharges."

References.—"Ency. Metrop.," Vol. IV. p. 220; Highton's "Elect. Tel."; Fahie, "Hist. of Elec. Tel.," pp. 175 and 176 and notes; Knight's "Mech. Dict.," Vol. II. p. 936; G. H. Browne, London, 1704, and in "Phil. Mag.," Vol. XVIII. p. 285, also note p. 83 of Ronalds' "Catalogue."

A.D. 1701–1702.—Le Brun (Pierre), French theologian (1661–1729), publishes his "Histoire Critique des Pratiques Superstitieuses," wherein he makes mention (Vol. I. p. 294) of the possibility of transmitting intelligence in the manner indicated by the Jesuit Leurechon.

He is also the author of "Lettres qui découvrent l'illusion des philosophes sur la baguette divinatoire," Paris, 1693 (Larousse's "Dictionnaire," Tome X. p. 292).

A.D. 1702.—Bion (Nicolas), French engineer and manufacturer of mathematical and astronomical instruments (1652–1733), is the author of "Usage des Astrolabes," which was shortly after followed by his well-known "Traité de la construction et des principaux usages des instruments de mathématique." In the preparation of the last nâmed, which was translated into German (Leipzig, 1713, Nuremberg, 1721) as well as into English (London, 1723, 1738), Bion admits the assistance afforded him by Lahire, Cassini and Delisle the younger.

The whole of Book VII (pp. 267–290) of the "Traité," is devoted to the description of instruments employed in navigation, the compass and the astrolabe in particular, with instructions for ascertaining the declination and variation.

Bion is also the author of "L'Usage des Globes Célestes et Terrestres et des sphères suivant les differents systèmes du monde," Amsterdam, 1700. Much of the matter, however, is said to have been copied by Bion from Pierre Polinière's "Expériences de Phisique," of which latter five editions were printed respectively in 1709, 1718, 1728, 1734 and 1741.

References.—"La Grande Encycl.," Vol. VI. p. 897; Michaud, "Biog. Univ.," Vol. IV. p. 354; Dr. J. Thomas, "Univ. Pr. Dict.," 1886, p. 386.

A.D. 1702.—Marcel (Arnold), Commissioner of the Navy at Arles, publishes a pamphlet dedicated to the King, and entitled "The Art of Making Signals, both by Sea and by Land," wherein he affirms that he has "communicated frequently at the distance of two leagues (in as short a space of time as a man could write down and form exactly the letters contained in the advice he would communicate), an unexpected piece of news that took up a page in writing." The particulars of this invention are, however, wanting.

Marcel reports many well-authenticated instances where, as already mentioned by Mæstro Giulio Cæsare (A.D. 1590), iron bars have become temporarily magnetic by position alone.

References.—Snow Harris, "Rudim. Mag.," I and II. pp. 91, 92; also "Emporium of Arts and Sciences," 1812, Vol. I. p. 301; *Phil. Trans.*, Vol. XXXVII. p. 294, also the following abridgments: Baddam, Vol. IX, 1745, p. 278; Eames and Martyn, Vol. VI. part. ii. p. 270; Hutton, Vol. VII. p. 540.

A.D. 1702.—Kæmpfer (Engelbrecht), German physician and naturalist (1651–1716), describes in his "Amœnitates Exoticæ," experiments made by him upon the electric *torpedo* (Leithead, 1837, Chap. XII). He insists that any person may avoid all sensation of the shock by merely holding the breath while touching the animal. This apparently improbable fact has since been confirmed, however, by many scientists; the accurate observations of Mr. Walsh (A.D. 1773) on the subject, reported in the *Phil. Trans.* for 1773–1774–1775, claiming especial attention (Larousse, "Dict.," Vol. IX. p. 1144).

A.D. 1704.—Amontons (Guillaume), an ingenious mechanician and scientist, exhibits before the royal family of France, and before the members of the Académie des Sciences, his system of communicating intelligence between distant points through the agency of magnifying glasses—telescopes. The "Mémoires de l'Académie," 1698–1705, contain an account of his many scientific productions.

References.—Larousse, "Dict.," Vol. I. pp. 282–283; Appleton's "Cyclop.," Vol. I. p. 432.

A.D. 1705.—Witson (Nicholaes), Burgomaster of Amsterdam, announces at p. 56 of his "Noord en Oost Tartarye," that the nautical compass was in use by the Coreans in the second half of the seventeenth century.

A.D. 1705.—Hauksbee (Francis), English natural philosopher and Curator of the Royal Society, makes, before the latter, several

experiments on the *mercurial phosphorus*. He shows that a considerable quantity of light can be produced by agitating mercury in partly exhausted as well as in thoroughly exhausted glass vessels. When the mercury is made to break into a shower, flashes of light are seen to start everywhere " in as strange a form as lightning."

He also showed light *in vacuo* produced by rubbing amber and by rubbing glass upon woollen. He says (Priestley, " Hist. and Present State of Electricity," London, 1775, p. 19) that every fresh glass first gave a purple and then a pale light, and that woollen, tinctured with salt or spirits, produced a new, strong and fulgurating light.

Hauksbee constructed a powerful electrical machine wherein the Von Guericke sulphur globe was replaced by one of glass, as had already been done by Sir Isaac Newton (at A.D. 1675). With it he found that upon exhausting the air, whirling the globe rapidly and placing his hand upon the outside, a strong light appeared upon the interior, and that the light would show itself also upon the outside when air was let into the globe (" Physico-Mech. Exp.," pp. 12, 14, 26, 32, 34).

The machine, which the celebrated mechanician Leupold had constructed at Leipzig for Mr. Wolfius, only differed from the original one made by Hauksbee in that the glass globe turned vertically instead of horizontally.

Other experiments with coated glass globes, globes of sulphur, etc., are detailed in the " Physico-Mech. Exp.," as indicated at pp. 21–24 of the Priestley work above alluded to. At the last-named page he says : " That Mr. Hauksbee, after all, had no clear idea of the distinction of bodies into electrics and non-electrics appears from some of his last experiments, in which he attempted to produce electrical appearances from metals, and from the reasons he gives for his want of success in those attempts."

Hauksbee also gave some attention to the study of the laws of magnetic force, and the results published in the *Phil. Trans.*, Vol. XXVII. for 1710–1712, p. 506, giving a law of force varying as the sesqui-duplicate ratio of the distances, were subsequently confirmed by Taylor and by Whiston in the *Phil. Trans.* for 1721 (Noad, " Manual of Elec.," 1859, p. 579).

References.—Aglave et Boulard, " Lumière Electrique," Paris, 1882, p. 18; Priestley, " Familiar Intr. to Study of Elec.," London, 1786, p. 60; *Phil. Trans.*, Vol. XXV. pp. 2327, 2332; Vol. XXVI, 1708–1709, pp. 82–92; Vol. XXIX, 1714–1716, p. 294 (with Brooke Taylor); also the following abridgments : Hutton, Vol. V. pp. 270, 307, 324, 344, 355, 411–416, 452, 509, 528, 696; Jones, Vol. IV. p. 295 ; Baddam, 1745, Vol. V. pp. 33–37, 41–43, 112, 114–117, 483 ; Thos. Thomson, " Hist. of the Roy. Soc.," London, 1812, p. 430; *Chemical News*, Vol. II. p. 147;

Nicolas Desmarets, "Expériences," etc., Paris, 1754, in "Recueil des Mémoires de l'Acad. des Sciences."

A.D. 1705.—Keill (John), M.A., F.R.S., Savilian Professor of Astronomy, is the author of "Introductio ad Veram Physicam, etc.," of which other editions appeared in 1725, 1739 and 1741, and a good English translation of which was published at Glasgow in 1776.

The last named is entitled "An Introduction to Natural Philosophy, or Lectures in Physics read in the University of Oxford in the Year 1700." In Lecture VIII he states: "It is certain that the magnetic attractions and directions arise from the structure of parts; for if a loadstone be struck hard enough, so that the position of its internal parts be changed, the loadstone will also be changed. And if a loadstone be put into the fire, insomuch that the internal structure of the parts be changed or wholly destroyed, then it will lose all its former virtue and will scarce differ from other stones. . . . And what some generally boast of, concerning effluvia, a subtile matter, particles adapted to the pores of the loadstone, etc., does not in the least lead us to a clear and distinct explication of these operations; but notwithstanding all these things, the magnetick virtues must be still reckoned amongst the occult qualities."

A.D. 1706.—Hartsoeker (Nicolas), Dutch natural philosopher, friend of Christian Huyghens, while Professor of Mathematics at Düsseldorf, writes his "Conjectures Physiques," four editions of which were published during the three years 1708, 1710 and 1712.

The Tenth Discourse of the Second Book (pp. 140–182) treats of the nature and properties of the loadstone and gives numerous observations concerning magnetical phenomena, which are well illustrated. He says that many ordinary stones have become magnetic after being long exposed to the air, in consequence of iron penetrating them. He believes that the native loadstone is made up of ordinary stone and of iron containing many small bodies through which run magnetic channels; that the latter are held together so strongly as to be disintegrated with difficulty, and that they are filled with a subtile matter which circulates incessantly through and around them.

The First Discourse of the Fourth Book treats of Meteors, and at pp. 91–99 of his "Eclaircissements, . . ." published in 1710 he gives further reports of his curious observations on magnetic phenomena.

References.—"Journal des Sçavans," Vol. XXIV for 1696, pp. 649–656.

For particulars of the very celebrated natural philosopher, Christian

Huyghens—Hugenius van Zuglichen (1629–1695) above alluded to, consult: the "Vita Hugenii," prefixed to his "Opera Varia," published by Van 'Sgravesande in 1724; "Meyer's Konversations-Lexikon," Leipzig und Wien, 1895, Vol. IX. pp. 93–94, also the biography, embracing a detailed list of his geometrical, mechanical, astronomical and optical works at pp. 536–538 of the "English Cyclopædia"; Vol. II. of Houzeau et Lancaster, "Bibliog. Générale," p. 169; "Le Journal des Savants" for May 1834, April 1846, July 1888, April 1896, Feb. 1898, Oct. 1899; "Histoire des Sciences Math. et Phys.," Maximilien Marie, Paris, 1888, Vol. V. pp. 15–140; "Hist. et Mém. de l'Acad. Roy. des Sc.," Vol. I. p. 307; Hartsoeker's biography at pp. 307–308 of the "Engl. Cycl.," Vol. III, 1867.[1]

A.D. 1707.—J. G. S. (not, as many suppose, Jean George Sulzer) publishes "Curious Speculations during Sleepless Nights," 8vo, Chemnitz, wherein appears the first account of the development, by heat, of electricity in the *tourmaline*, which latter, it is therein stated, was first brought from Ceylon by the Dutch in 1703. Another report of the above appears in the *Mémoires de l'Académie des Sciences* of Paris for 1717.

REFERENCE.—Beckmann, Bohn, 1846, Vol. I. pp. 86–98.

A.D. 1708.—Wall (Dr. William), a prominent English divine, communicates to the Royal Society (*Phil. Trans.*, Vol. XXVI. No. 314, p. 69) the result of his experiments, showing him to have been the first to establish a resemblance of electricity to thunder and lightning.

He found that, upon holding tightly in the hand a large bar of amber and rubbing it briskly against woollen cloths, "a prodigious number of little cracklings was heard, every one of which produced a small flash of light (spark); and that when the amber was drawn lightly through the cloth it produced a spark but no crackling." He observed that "by holding a finger at a little distance from the amber a crackling is produced, with a great flash of light succeeding it, and, what is very surprising, on its eruption it strikes the finger very sensibly, wheresoever applied, with a push or puff like wind. The crackling is fully as loud as that of charcoal on fire. . . . This light and crackling seem in some degree to represent thunder and lightning."

REFERENCES.—Bakewell, "Electric Science," p. 13; Aglave et Boulard, "Lumière Electrique," 1882, p. 17; Thos. Thomson, "An Outline of the Sciences of Heat and Electricity," London, 1830, pp. 314, 463; Thos. Thomson, "Hist of the Roy. Soc.," London, 1812, p. 431;

[1] "La perte de l'illustre M. Huygens est inestimable, peu de gens le savent autant que moi; il a égalé, à mon avis, la réputation de Galilée et de Descartes, et, aidé par ce qu'ils avaient fait, il a surpassé leurs découvertes." (Extracted from a letter written by Leibnitz to Bosange, July 26, 1695—"Journal des Savants," for Nov. 1905, "Oeuvres complètes de Christian Huygens," La Haye, 1905.)

see also the following abridgments of the *Phil. Trans.*; Hutton, Vol. V. p. 408 and Baddam of 1745, Vol. V. p. 111.

A.D. 1712.—The great Japanese Encyclopædia, *Wa-Kan-san siü tson-ye*, describes the compass, *zi-siak-no-fari*, at Vol. XV. folio 3, *recto* (Klaproth, " Lettre à M. de Humboldt," etc., 1834, p. 107).

A.D. 1717.—Lemery (Louis), two years after the death of his distinguished father, Nicolas Lemery, exhibits a stone (the *tourmaline*) brought from Ceylon, and announces, to the French Académie des Sciences, that it possesses the electrical property of attracting and repelling light bodies after being warmed.

Carl Linnæus (1707–1777) alludes to the experiments of Lemery, in his *Flora Zeylanica*, and mentions the stone under the name of *lapis electricus*. (See, for Carl Linnæus, " Thesaurus Litteraturæ Botanicæ," G. A. Pritzel, Lipsiæ, 1851, pp. 162–169, also " Guide to the Literature of Botany," by Benj. Daydon Jackson, London, 1881, pp. xxxvi, etc.)

The first scientific examination of the electric properties of the tourmaline was, however, made by Æpinus in 1756, and published in the Memoirs of the Berlin Academy. Æpinus showed that a temperature of between 99½° and 212° F. was necessary for the development of its attractive powers.

Of the electricity of crystals, Gmelin, in his " Chemistry " (Vol. I. p. 319), names the following discoverers : Æpinus (tourmaline)—see A.D. 1759; Canton (topaz)—see A.D. 1753; Brard (axinite)—see A.D. 1787; Haüy (boracite, prehnite, sphene, etc.)—see A.D. 1787; Sir David Brewster (diamond, garnet, amethyst, etc.)—see A.D. 1820; and Wilhelm Gottlieb Hankel (borate of magnesia, tartrate of potash, etc.).

References.—Becquerel, " Résumé," 1858, p. 11; Leithead, " Electricity," p. 239; " Ph. Hist. and Mem. of Roy. Ac. of Sc. at Paris," London, 1742, Vol. V. p. 216; " Journal des Sçavans," Vol. LXX for 1721, pp. 572–573 on the tourmaline.

A.D. 1720.—Grey—Gray (Stephen), a pensioner of the Charter House and Fellow of the Royal Society, makes known through his first paper in the *Phil. Trans.* the details of the important line of investigation which finally led to the discovery of the principle of electric conduction and insulation as well as to the fact, not the principle, of induction (see Æpinus, A.D. 1759). *Thus, to Grey is due the credit of having laid the foundation of electricity as a science.*

He proved that electricity can be excited by the friction of feathers, hair, linen, paper, silk, etc., all of which attract light bodies even at a distance of eight or ten inches. He next discovered that electricity can be communicated from excited bodies to bodies

incapable of ready excitation. When first suspending a hempen line with pack threads he could not transmit electricity, but when suspending the line with silken threads he transmitted the electrical influence several hundred feet. The latter he did at the suggestion of his friend Granville Wheeler—Wheler—(not Checler, as Aglave et Boulard have it in "Lumière Electrique," p. 20), thinking that "silk might do better than pack thread on account of its smallness, as less of the virtue would probably pass off by it than by the thickness of the hempen line which had been previously used." They both tried experiments with longer lines of pack thread, but failed, as they likewise did after substituting thin brass wire for the thread. This afterwards led to the discovery of other insulating substances, like hair, resin, etc. During the months of June 1729, and August 1730, Grey and Wheeler succeeded in transmitting electricity through pack thread supported by silken cords a distance of 765 feet, and through wire at a distance of 800–886 feet.

Grey demonstrated also that electric attraction is not proportioned to the quantity of matter in bodies, but to the extent of their surface, and he likewise discovered the conducting powers of fluids and of the human body. Of the cracklings and flashes of light he remarks: "And although these effects are at present but *in minimis*, it is probable, in time, there may be found out a way to collect a greater quantity of the electric fire, and consequently to increase the force of that power, which by several of those experiments, if we are permitted to compare great things with small, seems to be of the same nature with that of thunder and lightning" (*Phil. Trans.*, abridgment of John Martyn, Vol. VIII. p. 401).

Stephen Grey may be said to have continued his experiments while lying upon his death-bed, for, unable to write, he dictated to the last, as best he could, the progress he had made in his studies to Dr. Mortimer, the Secretary of the Royal Society (*Phil. Trans.*, 1735–1736, Vol. XXXIX. p. 400).

Grey's own description of a new electric planetarium deserves reproduction here: "I have lately made several new experiments upon the projectile and pendulous motions of small bodies by electricity; by which small bodies may be made to move about larger ones, either in circles or ellipses, and those either concentric or excentric to the centre of the large body about which they move, so as to make many revolutions about them. And this motion will constantly be the same way that the planets move around the sun, viz. from the right hand to the left, or from west to east. But these little planets, if I may so call them, move much faster in their apogeon than in the perigeon part of their orbits, which is directly contrary to the motion of the planets around the sun."

To this should be added the following description of the manner in which these experiments can be made: "Place a small iron globe, of an inch or an inch and a half in diameter, on the middle of a circular cake of rosin, seven or eight inches in diameter, greatly excited; and then a light body, suspended by a very fine thread, five or six inches long, held in the hand over the centre of the cake, will, of itself, begin to move in a circle around the iron globe, and constantly from west to east. If the globe is placed at any distance from the centre of the circular cake, it will describe an ellipse, which will have the same excentricity as the distance of the globe from the centre of the cake. If the cake of rosin be of an elliptical form, and the iron globe be placed in the centre of it, the light body will describe an elliptical orbit of the same excentricity with the form of the cake. If the globe be placed in or near one of the foci of the elliptical cake, the light body will move much swifter in the apogee than in the perigee of its orbit. If the iron globe is fixed on a pedestal an inch from the table, and a glass hoop, or a portion of a hollow glass cylinder, excited, be placed around it, the light body will move as in the circumstance above mentioned, and with the same varieties."

References.—Priestley, "Hist. and Present State of Elec.," 1775, pp. 26–42, 55–63; and "A New Universal History of Arts and Sciences," *Electricity*, Vol. I. p. 460; *Saturday Review*, August 21, 1858, p. 190; Wilson, "Treatise," 1752, Section IV. prop. i. p. 23, note; *Phil. Trans.*, Vol. XXXI. p. 104; Vol. XXXVII. pp. 18, 227, 285, 397; Vol. XXXIX. pp. 16, 166, 220, also the following abridgments: Hutton, Vol. VI. p. 490; Vol. VII. pp. 449, 536, 566; Vol. VIII. pp. 2, 51, 65, 316; Reid and Gray, London, 1733, Vol. VI. pp. 4–17 (Granville Wheler); Eames and Martyn, Vol. VI. part ii. pp. 7, 9, 15, and Part IV. p. 96; Vol. VII. pp. 18–20, 231; John Martyn, Vol. VIII. part ii. pp. 397, 403, 404 (Dr. C. Mortimer); Baddam, Vol. IX, 1745, pp. 145–160, 244, 272, 340, 497; "An Outline of the Sciences of Heat and Electricity," Thomas Thomson, London, 1830, p. 344; and Thos. Thomson's "Hist. of the Roy. Soc.," London, 1812, p. 431; Weld, "Hist. of Roy. Soc.," Vol. I. p. 466; "A course of lectures on Nat. Philos. and the Mechanical Arts," by Thos. Young, London, 1807, Vol. II. p. 417; "Hist. de l'Académie des Sciences," 1733, p. 31; "Jour. Litter." de 1732, à la Haye, pp. 183, 186, 187, 197; "Hist de l'Académie Royale de Berlin," 1746, p. 11; "Journal des Sçavans," Vol. CXXV for 1741, pp. 134–141, and Vol. CXXVI for 1742, pp. 252–263. For Granville Wheeler, consult *Phil. Trans.*, Vol. XLI. pp. 98, 118, also the following abridgments: Hutton, Vol. VIII. pp. 306–320; John Martyn, Vol. VIII. part ii. pp. 406, 412, 415. For Dr. C. Mortimer, consult *Phil. Trans.*, Vol. XLI. p. 112 and John Martyn's abridgments, Vol. VIII. part ii. pp. 404–412.

A.D. 1721.—Taylor (Brooke), LL.D., F.R.S. (1685–1731), an eminent English mathematician, past Secretary of the Royal Society, and one of the ablest geometers of his time—"the only one who, after the retreat of Newton, could safely enter the lists with the Bernoullis"—publishes his "Experiments on Magnetism" in *Phil. Trans.*, No. 368.

In order to arrive at a proper determination of the laws of magnetic force, Dr. Taylor—and also Whiston and Hauksbee—according to Sir David Brewster, considered "the deviation of a compass needle from the meridian, produced by the action of a magnet at different distances; and the conclusion which they all drew from their experiments was that the magnetic force was proportional to the sines of half the arcs of deviation, or nearly in the inverse sesqui-duplicate ratio of the distance, or as the square roots of the fifth powers of the distances. Dr. Taylor had already come to the conclusion that the force was different in various magnets, and decreased quicker at great distances than at small ones, an experimental fact, as shown by Sir W. S. Harris, 'Rud. Mag.,' Part III. p. 224."

In Dr. Thomas Thomson's "History of the Royal Society" we read, however (p. 461), that Brooke Taylor, and after him Musschenbroek, attempted without success to determine by experiment the rate at which the magnetic attractions and repulsions vary. This rate was successfully investigated by the subsequent experiments of Lambert, Robison and Coulomb. The nature of magnetic curves was first satisfactorily explained by Lambert, Robison and Playfair. Brooke Taylor gave four poles to a wire by touching it at one end or at various parts, as indicated in *Phil. Trans.*, Vol. XXIX. p. 294, and Vol. XXXI. p. 204.

References.—Whewell, "Hist of the Ind. Sciences," 1859, Vol. I. pp. 359, 375; Vol. II. p. 31; "General Biog. Dict.," London, 1816, Vol. XXIX. pp. 163–166; *Phil. Trans.* for 1714–1716, Vol. XXIX. p. 294 and the following abridgments: Hutton, Vol. VI. p. 528; Reid and Gray, Vol VI. pp. 17, 159; Hy. Jones, Vol. IV. part ii. p. 297; Eames and Martyn, Vol. VI. part ii. p. 253.

A.D. 1722.—Graham (George), a celebrated optician and instrument maker in London, is the first to distinctly make known the *diurnal and horary variations* of the magnetic needle, traces of which had been merely recognized as facts by Gellibrand, in 1634, and by the Missionary Father Guy-Tachard at Louvo, in Siam, during 1682. He finds that its northern extremity begins to move westward at about seven or eight o'clock in the morning, and continues to deviate in that direction until about two o'clock in the afternoon, when it becomes stationary; it soon begins to return to the eastward and becomes again stationary during the night. Graham made nearly a thousand observations, between the 6th of February and the 12th of May, 1722, and found that the greatest westerly variation was 14° 45′, and the least 13° 50′; in general, however, it varied between 14° and 14° 35′, giving 35′ for the amount of the daily variation.

Graham's discovery—afterwards amplified by Anders Celsius (A.D. 1740)—attracted but little attention until 1750, when the subject was ably taken up by Wargentin, Secretary to the Swedish Academy of Sciences. Between 1750 and 1759 Mr. John Canton made about 4000 observations on the same subject, and was followed by the Dutch scientist Gerard van Swieten, the favourite pupil of Boerhaave, with like results.

As Dr. Lardner states (" Lectures on Science and Art," 1859, Vol. II. p. 115), the same phenomenon has been observed more recently by Col. Beaufoy (at A.D. 1813), by Prof. Hansteen (at A.D. 1819) and by many others. He further states that Cassini, who observed the *diurnal* variation of the needle at Paris, found that neither the solar heat nor light influenced it, for it was the same in the deep caves constructed under the Observatory in Paris, where a sensibly constant temperature is preserved, and from which light is excluded, as at the surface. In northern regions these diurnal changes are greater and more irregular; while, toward the line, their amplitudes are gradually diminished until at length they disappear altogether.

It was Graham who first entertained the idea of measuring the magnetic intensity through the vibrations of the needle, a method subsequently used by Coulomb, and which many believe was invented by the latter. From the observations made by Humboldt and by Gay-Lussac in this manner, Biot has reduced the variation of intensity in different latitudes.

REFERENCES.—" *Am. Journal Science*," Vol. XXX. p. 225; Walker, " Magnetism," Chap. II; Fifth Dissertation of the Eighth " Britannica," Vol. I. p. 744; also *Phil. Trans.* 1724–1725, Vol. XXXIII. p. 332, and pp. 96–107 (" An Account of Observations Made of the Horizontal Needle at London, 1722–1723, by Mr. George Graham ") and the following abridgments: Reid and Gray, Vol. VI. pp. 170, 187; Hutton, Vol. VII. pp. 27, 94; Vol. IX. p. 495; Eames and Martyn, Vol. vi. part ii. pp. 28, 280, 290; Baddam, 1745, Vol. VIII. p. 20; John Martyn, Vol. X. part ii. p. 698; *An de chimie* for 1749, Vol. XXV. p. 310.

A.D. 1725.—Horrebow—Horreboe—(Peter), was a Danish physicist (1679–1764), who studied medicine for a time and then became a pupil of the celebrated mathematician and astronomer Olaus Rœmer (1644–1710, best known by his discovery of the finite velocity of light), whom he succeeded in the University of Copenhagen.

His earliest work, " Clavis Astronomiæ," first appeared during 1725, but it is only in the second and enlarged new edition of it in Horrebow's " Operum Mathematico-Physicorum," Havn. 1740, Vol. I. p. 317, that will be found the passage (s. 226) in which the luminous process of the sun is characterized as a perpetual northern

light. Humboldt, who mentions the fact ("Cosmos," 1859, Vol. V. p. 81) suggests that a comparison be made of Horrebow's statement with the precisely similar views held by Sir William Herschel (1738–1822) and Sir John Frederick William Herschel (1792–1871). He says that Horrebow, who did not confound gravitation with magnetism, was the first who thus designated the process of light produced in the solar atmosphere by the agency of powerful magnetic forces ("Mémoires de Mathématiques et de Physique, présentés à l'Académie Royale des Sciences," Vol. IX. 1780, p. 262; Hanow, in Joh. Dan. Titius's "Gemeinützige Abhand. über natür. Dinge," 1768, p. 102), and, with reference to the Herschels he thus expresses himself: "If electricity, moving in currents, develops magnetic forces, and if, in accordance with an early hypothesis of Sir Wm. Herschel (*Phil. Trans.* for 1795, Vol. LXXXV. p. 318; John Herschel, "Outlines of Astronomy," p. 238; also, Humboldt, "Cosmos," Vol. I. p. 189), the sun itself is in the condition of a perpetual northern light (I should rather say of an electro-magnetic storm) we should seem warranted in concluding that solar light transmitted in the regions of space by vibrations of ether, may be accompanied by electro-magnetic currents" ("Dict. of Nat. Biog.," for John and William Herschel, Vol. XXVI. pp. 263–274).

References.—Larousse, "Dict. Univ.," Vol. IX. p. 397; Wolf, "Hist. Ordbog.," Vol. VII. pp. 194–199; Nyerup, "Univ. Annalen"; Houzeau et Lancaster, "Bibliographie," 1882, Vol. II. p. 166.

Three of the children of Peter Horrebow, almost equally distinguished for their learning, are: Nicolas Horrebow (1712–1760), who made physical and astronomical observations in Iceland and published an able report thereon during 1752; Christian Horrebow (1718–1776), who succeeded his father in 1753 as astronomer in the Copenhagen University and who wrote several important scientific treatises; and Peter Horrebow (1728–1812), who was professor of mathematics and philosophy, and published works on geometry, meteorology and astronomy.

Much of interest concerning the above will also be found in the "Abstracts of Papers . . . Roy Soc.," Vol. II. pp. 208, 249, 251, and in the "Catalogue of Sc. Papers . . . Roy. Soc.," Vol. III. pp. 322–328; Vol. VI. p. 687; Vol. VII. p. 965.

A.D. 1726.—Wood (John), an English architect of considerable repute, is said to have shown that the electric fluid could be conveyed through wires a long distance, and, during the year 1747, one of the earliest applications of Wood's discovery was made by Dr.

William Watson (see A.D. 1745), who extended his experiments over a space of four miles, comprising a circuit of two miles of wire and an equal distance of ground.

REFERENCES.—Alexander Jones, "Sketch of the Elect. Teleg.," New York, 1852, p. 7; Charles F. Briggs, "Story of the Telegraph," 1858, p. 18.

A.D. 1729.—Hamilton (James), who became sixth Earl of Abercorn—also called Lord Paisley—publishes "Calculations and Tables relating to the attractive virtue of loadstones . . ." containing very valuable data and wherein he is the first to give the true law of the lifting capacity of magnets, as follows: "The principle upon which these tables are formed is this: That if two loadstones are perfectly homogeneous, that is if their Matter be of the same specifick parity, and of the same virtue in all parts of one stone, as in the other; and that like parts of their surfaces are cap'd or arm'd with iron; then the weights they sustain will be as the squares of the cube roots of the weights of the loadstones; that is, as their surfaces."

Gilbert treats of armed loadstones, Book II. chaps. xvii–xxii. In connection with the increased energy which magnets acquire by being armed, that is, fitted with a cap of polished iron at each pole, Dr. Whewell remarks that it is only at a later period any notice was taken "of the distinction which exists between the magnetical properties of soft iron and of hard steel; the latter being susceptible of being formed into *artificial magnets*, with permanent poles; while soft iron is only *passively magnetic*, receiving a temporary polarity from the action of a magnet near it, but losing this property when the magnet is removed. About the middle of the last century various methods were devised of making artificial magnets, which exceeded in power all magnetic bodies previously known" ("Hist. of the Ind. Sc.," 1859, Vol. II. p. 220).

Hamilton alludes to a loadstone weighing 139 grains, with a lifting power of 23,760 grains! We have referred, amongst others, to the loadstone belonging to Sir Isaac Newton at A.D. 1675, and to the wonderful collection belonging to Mr. Butterfield at A.D. 1809. A loadstone weighing twelve ounces, capable of lifting sixty pounds of iron, is referred to in Terzagus, "Musæum Septalianum," 1664, p. 42, while another weighing two and a half grains and lifting 783 grains is mentioned at p. 272, Vol. III. of the "Records of General Science"; and Salviatus ("Dialogues of Galileo," Dial. III) alludes to one in the Academy of Florence which, unarmed, weighed six ounces and could lift but two ounces, but when armed had a lifting power of 160 ounces. At pp. 317–318, Part III of Nehemiah Grew's "Musæum Regalis Societatis," London, 1681—also 1686—

allusion is made to a loadstone found in Devonshire, weighing about sixty pounds, which moved a needle nine feet distant. Grew then refers to Athan. Kircher and to Vincent Leotaud as having published what is said of the loadstone by Gilbert and others, and he likewise states : " Those that travail through the vast deserts of Arabia, have also a needle and a compass whereby they direct themselves in their way, as Mariners at sea [Majoli, ' Colloquia '] ; the power of the magnet dependeth not upon its bulk—the smaller being usually the stronger. . . ."

References.—*Phil. Trans.* for, 1729–1730, No. 412, Vol. XXXVI. p. 245, and for July 1888, also Hutton's abridgments, Vol. VII. p. 383 ; V. T. M. Van der Willigen, " Arch. du Musée Teyler," 1878, Vol. IV ; Jacobi Rohaulti, " Physica," 1718, Part III. cap. 8, p. 403, or the English translation by Dr. Clarke, 1728, Vol. II. p. 181 ; P. W. Hacker, " Zur theorie des magnetismus," Nurnberg, 1856 ; Ath. Kircher, " Magnes. . . ." 1643, lib. i. part ii. p. 63 ; Daniel Bernoulli, " Acta Helvetica," 1758, Vol. III. p. 223 ; Nic. Cabæus " Philosophia Magnetica," 1629, lib. iv. cap. 42, p. 407 ; Kenelme Digby, " The Nature of Bodies," 1645, Chap. XXII. p. 243 ; " Dict. of Nat. Biog ," Vol. XXIV. p. 185.

A.D. 1729–1730.—Savery (Servington), English mechanician, succeeds in imparting magnetism to hard steel bars three-fourths of an inch square and sixteen inches long, by fitting one bar with an armature at each end and touching other bars with it whilst held in the magnetic meridian in the line of the inclined needle.

It was shown by Savery that his artificial magnets were preferable to loadstones. The first recorded attempt to make artificial magnets is credited to one John Sellers, believed to be the author of " The Practical Navigator," of which the earliest edition appeared in 1669, and of " The Coasting Pilot," published about 1680. An " Answer to Some Magnetical Inquiries Proposed in (the preceding) No. 23, pp. 423–424," will be found in *Phil. Trans.* for 1667, Vol. II. pp. 478–479 and in the following abridgments : Baddam, 1745, Vol. I. p. 86 ; Hutton, Vol. I. p. 166 (as of No. 26, p. 478) ; John Lowthorp, Vol. II. p. 601. Reference is likewise made to this invention of Sellers at Vol. I. p. 86 of the " Memoirs of the Royal Society," London, 1739, and in a paper by Réaumur, in the " Mémoires de l'Académie Française " for the year 1723.

References.—Savery, " Magnetical Observations and Experiments," also *Phil. Trans.*, Vol. XXXVI. pp. 295–340 ; and the following abridgments : Hutton, Vol. VII. p. 400 ; Reid and Gray, Vol. VI. p. 166 ; Eames and Martyn, Vol. VI. p. 260 ; Baddam, 1745, Vol. IX. p. 57 ; Geo. Adams, " Essay on Electricity," 1785, p. 451.

A.D. 1731.—On the 25th of November the Royal Society were honoured by a visit from the Prince of Wales and the Duke of Lorraine, the last named being enrolled as a member during the

evening. Experiments were performed "On the strength of Lord Paisley's loadstone," "On Dr. Frobenius's phlogiston," and "On the electrical observations of Mr. Stephen Grey." These experiments which, it is said, "succeeded notwithstanding the largeness of the company," showed the facility with which electricity passes through great lengths of conductors and are worth noting as being the first of their nature.

A.D. 1732.—Régnault (Le Père Noël) gives in "Les Entretiens Physiques," etc., Vol. I. Nos. 15 and 16, the tables of the declination at Paris from the years 1600–1730, and treats at length of the merits of the loadstone and of the magnetic needle.

In Vols. II, IV and V he discourses about the extent of the magnetic fluid and explains the phenomena of meteors, St. Elmo's fire, thunder, etc., besides recording the experiments of Grey, Dufay and others.

A.D. 1733.—Dufay (Charles François de Cisternay), French scientist and superintendent of the *Jardin du Roi*, now the *Jardin des Plantes*, of Paris (in which latter position he was succeeded by Buffon), communicates to the French Academy of Sciences the history of electricity brought down to the year 1732 (*Dantzig Memoirs*, Vol. I. p. 195).

He is said to have originated the theory of two kinds of electricity permeating matter and producing all the known phenomena of attraction, repulsion and induction, though the honour of this important discovery should be shared by M. White, who was associated at one time with Stephen Grey and who, it appears, independently discovered the fact while in England. Dufay thus announces his discovery: ". . . there are two kinds of electricity, very different from one another, one of which I call *vitreous* (positive) and the other *resinous* (negative) electricity. The first is that of glass, rock crystal, precious stones, hairs of animals, wool and many other bodies. The second is that of amber, copal, gum-lac, silk, thread, paper and a vast number of other substances. The characteristics of these two electricities are that they repel themselves and attract each other. Thus a body of the vitreous electricity repels all other bodies possessed of the vitreous, and, on the contrary, attracts all those of the resinous electricity. The resinous also repels the resinous and attracts the vitreous. From this principle one may easily deduce the explanation of a great number of the phenomena; and it is probable that this truth will lead us to the discovery of many other things" (see Franklin, at A.D. 1752, and Symmer, at A.D. 1759).

Upon repeating Grey's experiments, Dufay observed, amongst other things, that, by wetting pack thread, electricity was more readily transmitted through it, and he was enabled thus easily to convey the fluid a distance of 1256 feet, though the wind was high and although the line made eight returns.

References.—Fontenelle, "Eloge"; Priestley, "History and Present State of Electricity," 1775, Period IV. pp. 43–54; Sturgeon, *Lectures*, 1842, p. 23; "An Epitome of El. and Mag.," Philad., 1809, p. 29; *Mém. de l'Acad. Royale des Sciences* for 1733, pp. 23, 28, 76, 83, 233–236, 251, 252, 457; also for the years 1734, pp. 303, 341, and 1737, pp. 86, 307; *Phil. Trans.*, Vol. XXXVIII. p. 258; also the following abridgments: Hutton, Vol. VII. p. 638; John Martyn, Vol. VIII. part ii. p. 393; Baddam, Vol. IX. p. 497; Thos. Thomson, "An Outline of the Sciences of Heat and Electricity," London, 1830, p. 344 and Thos. Thomson, "Hist. of the Roy Soc.," London, 1812, p. 432; "Electricity in the Service of Man," R. Wormell (from the German of Dr. Urbanitzky), London, 1900, p. 14; "Journal des Sçavans," Vol. XCIII for 1731, pp. 383–388; Vol. C for 1733, p. 244; Vol. CIV for 1734, p. 479; Vol. CXII for 1737, p. 65; Vol. CXV for 1738, p. 173; Vol. CXXIX for 1743, p. 501.

A.D. 1733.—Winckler (Johann Heinrich), a philosopher of Wingendorf, Saxony, and Professor of Languages in the University of Leipzig, first uses a fixed cushion in the electric machine for applying friction instead of by means of the hand, and is, by many, believed to have been the first to suggest the use of conductors as a means of protection against lightning (see B.C. 600).

In March 1745, Winckler read a paper before the Royal Society, in which he describes machines for rubbing tubes and globes, also a contrivance with which he can give his globes as many as 680 turns in a minute. Priestley states that the German electricians generally used several globes at a time and that they could excite such a prodigious power of electricity from "globes, whirled by a large wheel and rubbed with woollen cloth or a dry hand, that, if we may credit their own accounts, the blood could be drawn from the finger by an electric spark; the skin would burst and a wound appear, as if made by a caustic."

During the year 1746 Winckler made use of common electricity for telegraphic communications by the discharge of Leyden jars through very long circuits, in some of which the River Pleisse formed a part, and it may be added that Joseph Franz had previously discharged the contents of a jar through 1500 feet of iron wire while in the city of Vienna.

References.—*Phil. Trans.*, Vol. XLIII. p. 307; Vol. XLIV. pp. 211, 397; Vol. XLV. p. 262; Vol. XLVII. p. 231; Vol. XLVIII. p. 772; also following abridgments: Hutton, Vol. IX. pp. 74, 109, 251, 345, 494; Vol. X. pp. 197, 529; John Martyn, Vol. X. part ii. pp. 269, 273, 327,

345, 399; Priestley, 1775, on the discoveries of the Germans, pp. 70–77; "Thoughts on the Properties," etc., Leipzig, 1744, pp. 146, 149.

A.D. 1733.—Brandt (Georg), Swedish chemist, gives in the "Memoirs of the Academy" of Upsal an account of the experiments made by him to show the possibility of imparting magnetism to substances which are not ferruginous. He proved it in the case of the metal cobalt, and during the year 1750 the able discoverer of nickel, Axel. F. de Cronstedt, showed that the latter is likewise susceptible of this property.

References.—Thomas, "Dict. of Biog.," 1871, Vol. I. p. 428; English Cyclopædia (Biography Supplement), 1872, p. 423.

A.D. 1734.—Polinière (Pierre), French physician and experimental philosopher (1671–1734), member of the Society of Arts, entirely revises the fourth edition of his "Expériences de Phisique" originally issued in 1709. While the second volume contains but a short chapter relative to electricity, meteoric disturbances, etc., the remainder of the work gives very curious and interesting experiments with the loadstone, making allusion to the observations of John Keill, besides treating of the declination of the needle, etc.

References.—"New Gen. Biog. Dict.," London, 1850, Vol. XI. p. 177; Moréri, "Grand Dict. Hist."; "Biog. Univ." (Michaud), Vol. XXXIII. p. 637; "Nouv. Biog. Gén." (Hœfer), Vol. XL. p. 614; Chaudon, "Dict. Hist. Univ."

A.D. 1734.—Swedenborg (Emanuel), founder of the Church of New Jerusalem, details in his "Principia Rerum Naturalium," etc., the result of experiments and sets forth the laws relating to magnetic and electric forces and effects. The first explicit treatise upon the close relationship existing between magnetism and electricity was, however, written fourteen years later by M. Laurent Béraud (1703–1777), Professor of Mathematics at the College of Lyons. Both Swedenborg and Béraud recognized the fact that it is, as Fahie expresses it, the same force, only differently disposed which produces both electric and magnetic phenomena.

In "Results of an Investigation into the MSS. of Swedenborg," Edinburgh, 1869, p. 7, No. 16, Dr. R. L. Tafel makes following entry:

"A treatise on the magnet, 265 pages text and 34 pages tables, quarto. This work is a digest of all that had been written up to Swedenborg's time on the subject, with some of his own experiments. According to the title page, Swedenborg had intended it for publication in London during the year 1722."

The "Principia Rerum Naturalium" is the first volume of Swedenborg's earliest great work, "Opera Philosophica et Mineralia," originally published in Leipzig and Dresden 1734, which has justly been pronounced a very remarkable cosmogony. In the "Principia," Part I. chap. ix., is to be found his treatment of what he calls the second or magnetic element of the world; in Part III. chap. i. he gives a comparison of the sidereal heaven with the magnetic sphere, but he devotes the whole of Part II to the magnet in following chapters:

I. On the causes and mechanism of the magnetic forces;
II. On the attractive forces of two or more magnets, and the ratio of the forces to the distances;
III. On the attractive forces of two magnets when their poles are alternated;
IV. On the attractive forces of two magnets when their axes are parallel or when the equinoctial of the one lies upon the equinoctial of the other;
V. On the disjunctive and repulsive forces of two or more magnets when the cognomical or inimical poles are applied to each other;
VI. On the attractive forces of the magnet and of iron;
VII. On the influence of the magnet upon ignited iron;
VIII. On the quantity of exhalations from the magnet and their penetration through hard bodies, etc.;
IX. On the various modes of destroying the power of the magnet; and on the chemical experiments made with it;
X. On the friction of the magnet against iron, and on the force communicated from the former to the latter;
XI. On the conjunctive force of the magnet, as exercised upon several pieces of iron;
XII. On the operation of iron and of the magnet upon the mariner's needle; and on the reciprocal operation of one needle upon another;
XIII. On other methods of making iron magnetical;
XIV. The declination of the magnet calculated upon the foregoing principles;
XV. On the causes of the magnetic declination;
XVI. Calculation of the declination of the magnet for the year 1722, at London.

REFERENCES.—Béraud, "Dissertation," etc., Bordeaux, 1748; also Priestley, 1775, p. 191; "Biographie Universelle," Vol. III. p. 687; "Biog. Génér.," Vol. XLIV. pp. 690–703; Daillant de la Touche, "Abrégé des ouvrages de Swedenborg," 1788; J. Clowes,

"Letters on the writings of Swedenborg," 1799; "Svenskt Biografiskt Handlexikon," Herm. Hofberg, Stockholm, pp. 368–369; "Swedenborg and the Nebular Hypothesis," Magnus Nyrén, astronomer at Observatory of Pulkowa, Russia, translated from the "Viert el jahrschrift der Astronomischen Gesellschaft," Leipzig, 1879, p. 81, by Rev. Frank Sewall.

A.D. 1735–1746.—Ulloa (Don Antonio de), Spanish mathematician, who left Cadiz May 26, 1735, for South America, whither he was sent with Condamine and other French Academicians, as well as with Spanish scientists, to measure a degree of the meridian, returned to Madrid July 25, 1746, and shortly after gave an account of his experiences during an absence of eleven years and two months.

In his "Voyage Historique de l'Amérique Méridionale," Amsterdam and Leipzig, 1752, he speaks (Vol. I. pp. 14–18 and Vol. II. pp. 30–31, 92–94, 113, 123, 128) of the defective magnetic needles given him as well as of the means of correcting them, and he details at great length the variations of the needle observed during the voyage. He also alludes to the variation charts of Dr. Halley and to the alterations therein made by advice of William Mountaine and Jacob Dooson—James Dodson—of London, as well as to the methods of ascertaining the variation of the magnetic needle pointed out both by Manuel de Figueyredo, at Chaps. IX–X of his "Hidrographie ou Examen des Pilotes," printed at Lisbon in 1608, and by Don Lazare de Flores at Chap. I, part ii. of his "Art de Naviguer," printed in 1672. The latter, he says, asserts, in Chap. IX, that the Portuguese find his method so reliable that they embody it in all the instructions given for the navigation of their vessels.

At pp. 66, 67, Chap. X of vol. ii. Ulloa makes the earliest recorded reference to the *aurora australis*, as follows: "At half-past ten in the evening, and as we stood about two leagues from the island of *Tierra de Juan Fernandez*, we observed upon the summit of a neighbouring mountain a very brilliant and extraordinary light. . . . I saw it very distinctly from its inception, and I noticed that it was very small at first, and gradually extended until it looked like a large, lighted torch. This lasted three or four minutes, when the light began to diminish as gradually as it had grown, and finally disappeared."

Incidentally, it may be stated here that the very learned Dr. John Dalton reported having seen the *aurora australis* in England, and to have besides observed the *aurora borealis* as far as 45° latitude south (see accounts in *Philosophical Transactions*, *Philosophical Magazine*, *Manchester Transactions* and *Nicholson's Journal*), while Humboldt remarks ("Cosmos," 1849, Vol. I. p. 192, note) that in south polar bands, composed of very delicate clouds,

observed by Arago, at Paris, on the 23rd of June, 1844, dark rays shot upward from an arch running east and west, and that he had already made mention of black rays resembling dark smoke, as occurring in brilliant nocturnal northern lights.

References to the *aurora australis* are made by the naturalist John Reinhold Forster, in the article on " Aurora Borealis " of the " Encycl. Britannica."

For Mountaine and Dodson, consult the *Phil. Trans.*, Vol. XLVIII. p. 875; Vol. L. p. 329, also Hutton's abridgments, Vol. XI. p. 149.

A.D. 1738.—Boze—Böse—(Georg Matthias) (1710–1761), Professor of Philosophy at Wittemburg, publishes his " Oratio inauguralis de electricitate," which is followed, in 1746, by " Recherches sur la cause et sur la véritable théorie de l'électricité," and, in 1747, by his completed " Tentamina electrica."

To him is due the introduction in the electrical machine of the prime conductor, in the form of an iron tube or cylinder. The latter was at first supported by a man insulated upon cakes of resin and afterward suspended by silken strings. M. Boze discovered that capillary tubes discharging water by drops give a continuous run when electrified. He also conveyed electricity by a jet of water from one man to another, standing upon cakes of resin, at a distance of six paces, and likewise employed the jet for igniting alcohol as well as other liquids.

References.—Alglave et Boulard, 1882, p. 22, also Priestley, 1775, upon " Miscellaneous Discoveries," likewise " Nouv. Biog. Générale " (Hœfer), Vol. VI. p. 772; " La Grande Encycl.," Vol. VII. p. 454; " Journal des Sçavans," Vol. LXIII for 1718, p. 485; *Phil. Trans.* for 1745, Vol. XLIII. p. 419, and for 1749, Vol. XLVI. p. 189; also Hutton's abridgments, Vol. IX. pp. 127, 681; and J. Martyn's abridgments, Vol. X. part ii. pp. 277, 329.

A.D. 1739.—Desaguliers (Jean Theophile), chaplain to his Grace the Duke of Chandos, gives an account of his first experiments on the phenomena of electricity at pp. 186, 193, 196, 198, 200, 209, 634, 637, 638 and 661 of Vol. XLI of the *Phil. Trans.* for 1739. Some of these experiments were made on the 15th of April, 1738, at H.R.H. the Prince of Wales' house at Cliefden.

He was the first to divide bodies into " electrics," or non-conductors, and " non-electrics," or conductors. He ranked pure *air* amongst his electrics (Tyndall, Lecture I) and stated that " cold air in frosty weather, when vapours rise least of all, is preferable for electrical purposes to warm air in summer, when the heat raises the vapours " (*Phil. Trans.*, John Martyn abridgment, Vol. VIII. p. 437). It was Desaguliers who announced that he could render bars of iron magnetic, either by striking them sharply against the

ground while in a vertical position or by striking them with a hammer when placed at right angles to the magnetic meridian.

His "Dissertation Concerning Electricity," London, 1742, which won for him the grand prize of the Bordeaux Academy, is said to be the second work on the subject published in the English language, the first having been Boyle's "Mechanical Origin and Production of Electricity," mentioned at A.D. 1675.

Desaguliers was the second to receive the Copley medal, it having been previously bestowed by the Royal Society only upon Stephen Grey, who obtained it in 1731 and 1732 for his "New Electrical Experiments." The list of recipients of this distinguished honour, given by C. R. Weld at p. 385, Vol. I of the "History of the Royal Society," shows that Desaguliers received *three* Copley medals; these were awarded him during the years 1734, 1736 and 1741, for his "Experiments in Natural Philosophy." John Canton was given two of the medals, in 1751 and 1764, the only other electrician similarly favoured being Michael Faraday, who received them during the years 1832 and 1838, while Sir Humphry Davy is credited with only one, conferred upon him in 1805.

> "Can Britain . . .
> . . . Permit the weeping muse to tell
> How poor neglected Desaguliers fell?
> How he, who taught two gracious kings to view,
> All Boyle ennobled, and all Bacon knew,
> Died in a cell, without a friend to save,
> Without a guinea, and without a grave?"
> Cawthorn, "Vanity of Human Enjoyments," V. 147–154.

In the year 1742, Desaguliers received the prize of the *Académie Royale de Bordeaux* for a treatise on the electricity of bodies, which latter was separately published at the time in a quarto volume of twenty-eight pages. The same Academy had previously conferred important prizes for dissertations, upon the nature of thunder and lightning by Louis Antoine Lozeran du Fech in 1726, upon the variations of the magnetic needle by Nicolas Sarrabat in 1727, and also subsequently decreed similar awards, to Laurent Béraud for an essay on magnets in 1748, to Denis Barberet for a treatise on atmospherical electricity in 1750, and to Samuel Theodor Quellmalz for a dissertation on medical electricity in 1753.

REFERENCES.—*Phil. Trans.*, Vol. XL. p. 385; Vol. XLII. pp. 14, 140; also the following abridgments: Hutton, Vol. VIII. pp. 246–248, 340, 346, 350–358, 470–474, 479, 546, 584; John Martyn, Vol. VIII. part ii. pp. 419, 422–444, 740. Very interesting reading is afforded by M. Desaguliers through the observations he made on the magnets having more poles than two. These will be found recorded in *Phil. Trans.* for 1738, p. 383 and in Hutton's abridgments, Vol. VIII. p. 246; Thomson, "Hist. Roy. Soc.," 1812, pp. 433, 434; "Gen. Biog. Dict.," Alex. Chalmers, London, 1811, Vol. XI. pp. 489–493.

A.D. 1740.—Celsius (Anders), who filled the chair of astronomy at Upsal, is first to point out the great utility of making simultaneous observations over a large extent of territory and at widely different points. He states (*Svenska Vetenskaps Academiens Handlingar* for 1740, p. 44) that a simultaneity in certain extraordinary perturbations, which had caused a horary influence on the course of the magnetic needle at Upsal and at London, afforded proof "that the cause of these disturbances is extended over considerable portions of the earth's surface, and is not dependent upon accidental local actions."

In the following year (1741), Olav Hiörter, who was Celsius' assistant, discovered and measured the influence of polar light on magnetic variation. His observations were subsequently carried on in conjunction with Celsius, and were improved upon by Wargentin (A.D. 1750) and by Cassini (A.D. 1782–1791).

References.—Walker, "Ter. and Cos. Magnetism," p. 116; also Humboldt, "Cosmos," *re* "Magnetic Disturbances," and Vol. II. p. 438, of Weld's "History of the Royal Society."

A.D. 1742.—Gordon (Andreas), a Scotch Benedictine monk (1712–1757), Professor of Philosophy at Erfurt, abandons the use of glass globes (Newton, at A.D. 1675 and Hauksbee, at A.D. 1705), and is the first to employ a glass cylinder, the better to develop electricity. His cylinder, eight inches long and four inches wide, is made to turn by means of a bow with such rapidity that it attains 680 revolutions per minute.

Priestley says ("Discovery of Germans," Part I. period vii.) that Gordon "increased the electric sparks to such a degree that they were felt from a man's head to his foot, so that a person could hardly take them without falling down with giddiness; and small birds were killed by them. This he effected by conveying electricity, with iron wires, to the distance of 200 ells (about 250 yards) from the place of excitation."

References.—*Dantzig Memoirs*, Vol. II. pp. 358, 359, and Nollet, "Recherches," etc., p. 172. See also Gordon's "Phenomena Electricitatis Exposita," Erford, 1744 and 1746; "Philosophia," 1745; "Tentamen . . . Electricitatis," 1745; "Versuche . . . einer Electricität.," 1745–1746.

A.D. 1743.—Hausen (Christian Augustus), Professor of Mathematics at Leipzig, publishes his "Novi profectus in historia electricitatis," and is the first to revive the use of the glass globe introduced by Newton (A.D. 1675) and employed with great effect by Hauksbee (A.D. 1705).

In Watson's "Expériences et observations sur l'électricité,"

is shown an electrical machine constructed by Hausen and differing but slightly from the one alluded to herein at A.D. 1705 as made for M. Wolfius. In this illustration a lady is pressing her hand against the glass globe, which is being rotated rapidly, thus developing upon its surface the vitreous electricity, while the resinous electricity passes through her body to the earth. The young man who is suspended and insulated by silken cords, represents the prime conductor introduced by Prof. Boze (A.D. 1738). The vitreous electricity passes from the surface of the glass globe, through his feet and entire body, and is communicated by his hand to the young girl, who stands upon a large section of resin, and is able to attract small parcels of gold leaf by means of the electric fluid. Another machine, taken from the same French work (originally published at Paris in 1748), is said to have been at that time much in use throughout Holland and principally at Amsterdam. The man rotates a glass globe, against which the operator presses his hand, and the electricity is conveyed through the metallic rod supported by silk-covered stands and held by a third party, who is igniting spirits in the manner indicated at the A.D. 1744 date.

REFERENCE.—*Dantzig Memoirs*, Vol. I. pp. 278, 279.

A.D. 1743.—Boerhaave—Boerhaaven—(Hermann), illustrious physician, mathematician and natural philosopher (1668–1738), who held the chairs of theoretical medicine, practical medicine, botany and chemistry at the University of Leyden, F.R.S. and member French Academy of Sciences, writes an Essay on the virtue of Magnetical Cures, of which there were subsequently many editions and translations in different languages.

One of his biographers calls him "the Galen, the Ibn Sina, the Fernel of his age." Another remarks that he was, perhaps, the greatest physician of modern times: "A man who, when we contemplate his genius, his erudition, the singular variety of his talents, his unfeigned piety, his spotless character, and the impress which he left not only on contemporaneous practice, but on that of succeeding generations, stands forth as one of the brightest names on the page of medical history, and may be quoted as an example not only to physicians, but to mankind at large. No professor was ever attended, in public as well as at private lectures, by so great a number of students, from such distant and different parts, for so many years successively; none heard him without conceiving a veneration for his person, at the same time that they expressed their surprise at his prodigious attainments; and it may be justly

affirmed, that none in so private a station ever attracted a more universal esteem."

References.—" Biographica Philosophica," Benj. Martin, London, 1764, pp. 478–483; " Eloge de Boerhaave," by Maty, Leyde, 1747, and by Fontenelle, 1763, T. VI; his life, written by Dr. Wm. Burton, London, 1736; Van Swinden, " Recueil," etc., La Haye, 1784, Vol. II. p. 354, note; " La Grande Encyclopédie," Tome VII. p. 42; " Biographie Générale," Tome VI. pp. 352–357; " Biographie Universelle," Vol. IV. pp. 529–555; Ninth " Encycl. Britannica," Vol. III. p. 854; " Histoire Philosophique de la Médecine," Etienne Tourtelle, Paris, An. XII. (1807), Vol. II. pp. 404–446; " Bibl. Britan." (Authors), Rob. Watt, Edinburgh, 1824, Vol. I. p. 127; " The Edinburgh Encyclopædia," 1830, Vol. III. pp. 628–630 or the 1813 ed., Vol. III. pp. 612–614; G. A. Pritzel, " Thesaurus Literaturæ Botanicæ," Lipsiæ, 1851, p. 26.

A.D. 1744.—Ludolf—Leudolff—(Christian Friedrich), of Berlin, first exhibits, January 23, the ignition of inflammable substances by the electric spark. This he does in the presence of hundreds of spectators, on the occasion of the opening of the Royal Academy of Sciences by Frederick the Great of Prussia, when fire is set to sulphuric ether through a spark from the sword of one of the court cavaliers (see notes on Tyndall's second lecture, 1876, p. 80).

It was likewise at this period Ludolf the younger demonstrated that the luminous barometer is made perfectly electrical by the motion of the quicksilver, first attracting and then repelling bits of paper, etc., suspended by the side of the tube, when it was enclosed in another tube out of which the air was extracted (*Dantzig Memoirs*, Vol. III. p. 495).

A.D. 1744–1745.—Waitz (Jacob Siegismund von), a German electrician, writes three essays in Dutch and one in French, and is given the prize of fifty ducats proposed by the Berlin Academy of Sciences for the best dissertation on the subject of electricity. In the following year he makes experiments, with Etienne François du Tour, to show the destruction of electricity by flame, and, later on, with Prof. Georg Erhard Hamberger, he proves conclusively that the motion of quicksilver in a glass vessel out of which the air is extracted has the power of moving light bodies. Jean Nicolas Sebastien Allamand subsequently found that it was immaterial whether the vessel had air in it or not.

References.—Tyndall's Notes on Lecture II, also *Dantzig Memoirs*, Vol. II. pp. 380, 426, and M. du Tour's " Recherches sur les Différents Mouvements de la Matière Electrique," Paris, 1760.

A.D. 1745.—Kratzenstein (Christian Gottlieb), Professor of Medicine at Halle, author of " Versuch einer Erklarung," etc., and of " Theoria Electricitatis," etc., is said to have first successfully employed electricity in the relief of sprains, malformations, etc.

He observed that a man's pulse, which had beat eighty in a second before he was electrified, immediately after beat eighty-eight, and was soon increased to ninety-six.

Kratzenstein is reported (Mary Somerville, " Physical Sciences," Section XVII.) to have made instruments which articulated many letters, words and even sentences, and somewhat similar in construction to those alluded to at A.D. 1620 (De Bergerac), and A.D. 1641 (John Wilkins), some of which may truly be said to strongly suggest the modern phonograph.

Albertus Magnus constructed, after thirty years of experimentation, a curious machine which sent forth distinct vocal sounds, at which the very learned scholastic philosopher Saint Thomas Aquinas (" Angel of the Schools ") was so much terrified that he struck the contrivance with his stick and broke it. Bishop Wilkins alludes to this machine as well as to a brazen head devised by Friar Bacon, which could be made to utter certain words (" Journal des Savants " for 1899, and J. S. Brewer, " F. Rog. Bacon," 1859, p. xci; also, " How Fryer Bacon made a Brasen Head to Speake," at pp. 13–14 of the " Famous Historie of Fryer Bacon published at London for Francis Groue ").

Incidentally, it may be mentioned that Wolfgang von Kempelen, Aulic Counsellor to the Royal Chamber of the Domains of the Emperor of Germany, after witnessing some magnetic games shown to the Empress Maria Theresa at Vienna, constructed, during the year 1778, a speaking machine which " gave sounds as of a child three or four years of age, uttering distinct syllables and words " (Wm. Whewell, " Hist. of the Inductive Sciences," Vol. II. chap. vi.; J. E. Montucla, " Hist. des Mathém," Vol. III. p. 813).

La Nature, Paris, May 6, 1905, pp. 353–354, illustrates the *speaking head* of l'Abbé Mical presented by him to the French Academy of Sciences July 2, 1783, and alludes to those of Albertus Magnus, Wolfgang von Kempelen, C. G. Kratzenstein, etc.

Two more curious productions, in pretty much the same line as Bergerac's, can, with equal propriety, be inserted here.

The first is taken from the April number, 1632, of the *Courier Véritable*, a little monthly publication in which novel fancies were frequently aired: " Captain Vosterloch has returned from his voyage to the southern lands, which he started on two years and a half ago, by order of the States-General. He tells us, among other things, that in passing through a strait below Magellan's, he landed in a country where Nature has furnished men with a kind of sponge which holds sounds and articulations as our sponges hold liquids. So, when they wish to dispatch a message to a distance, they speak to one of the sponges, and then send it to their friends. They,

receiving the sponges, take them up gently and press out the words that have been spoken into them, and learn by this admirable means all that their correspondents desire them to know."

The second is the production of one Thomas Ward, theological poet, who was born in 1640 and died in 1704. In the second canto of one of his poems occur these words :

> " As Walchius could words imprison
> In hollow canes so they, by reason,
> Judgment and great dexterity,
> Can bottle words as well as he;
> And can from place to place convey them,
> Till, when they please, the *reed* shall say them;
> Will suddenly the same discharge,
> And hail-shot syllables at large
> Will fly intelligibly out
> Into the ears of all about :
> So that the *auditors* may gain
> Their meaning from the breach of cane."

References.—Priestley, " History," etc., 1775, p. 374, and *Dantzig Memoirs*, Vol. I. p. 294.

A.D. 1745.—Grummert (Gottfried Heinrich), of Biala, Poland, first observes the return of the electric light *in vacuo*. In order to ascertain whether an exhausted tube would give light when it was electrified, as well as when it was excited, he presented one eight inches long and a third of an inch wide, to the electrified conductor, and was surprised to find the light dart very vividly along the entire length of the tube. He likewise observed that some time after the tube had been presented to the conductor, and exposed to nothing but the air, it gave light again without being brought to an electrified body (see *Dantzig Memoirs*, Vol. I. p. 417).

A.D. 1745.—Dr. Miles (Rev. Henry), of Tooting, D.D. (1698–1763) reads, March 7, before the English Royal Society a paper indicating the possibility of kindling phosphorus by applying to it an excited electric without the approach of a conducting body. This gentleman's tube happening to be in excellent order upon this occasion, he observed, and doubtless was the first to notice, *pencils of luminous rays*, which he called *coruscations*, darting from the tube without the aid of any conductor approaching it.

In a paper which Dr. Miles read before the same Society on the 25th of January, 1746, he gave an account of other equally interesting experiments, one of which was the kindling of ordinary lamp spirits with a piece of black sealing wax excited by dry flannel or white and brown paper.

References.—" Dict. Nat. Biog.," Sidney Lee, Vol. XXXVII. p. 378; *Phil. Trans.*, Vol. XLIII. pp. 290, 441; Vol. XLIV. pp. 27, 53,

78, 158, and the following abridgments: Hutton, Vol. IX. pp. 107, 136, 191, 198, 207, 213, 232; John Martyn, Vol. X. part ii. pp. 272, 277, 317, 319, 322–323, 325.

A.D. 1745.—This period was to witness a discovery which, according to Professor Tyndall, "*throws all former ones in the shade,*" and which Dr. Priestley calls "*the most surprising yet made in the whole business of electricity.*" This was the accumulation of the electric power in a glass phial, called the Leyden jar after the name of the place where the discovery was made. It was first announced in a letter to Von Kleist, dean of the cathedral of Kamin—Cammin—in Pomerania, dated the 4th of November, 1745, and addressed to Dr. Lieberkühn, who communicated it to the Berlin Academy. The following is an extract: "When a nail or a piece of thick brass wire is put into a small apothecary's phial and electrified, remarkable effects follow; but the phial must be very dry or warm; I commonly rub it over beforehand with a finger, on which I put some pounded chalk. If a little mercury, or a few drops of spirit of wine, be put into it, the experiment succeeds the better. As soon as this phial and nail are removed from the electrifying glass, or the prime conductor to which it has been exposed is taken away, it throws out a pencil of flame so long that, with this burning machine in my hand, I have taken above sixty steps in walking about my room; when it is electrified strongly I can take it into another room and there fire spirits of wine with it. If while it is electrifying I put my finger, or a piece of gold which I hold in my hand, to the nail, I receive a shock which stuns my arms and shoulders."

It is said that Cunæus, rich burgess of Leyden, accidentally made the same discovery in January 1746. It appears that Pieter Van Musschenbroek, the celebrated professor, while experimenting with his colleagues, Cunæus and Allamand, observed that excited bodies soon lost their electricity in the open air, attributable to the vapours and effluvia carried in the atmosphere, and he conceived the idea that the electricity might be retained by surrounding the excited bodies with others that did not conduct electricity. For this purpose he chose water, the most readily procured non-electric, and placed some in a glass bottle. No important results were obtained until Cunæus, who was holding the bottle, attempted to withdraw the wire which connected with the conductor of a powerful electric machine. He at once received a severe shock in his arms and breast, as did also the others upon renewing the experiment. In giving an account of it to the great scientist, René de Réaumur, Musschenbroek remarked: "For the whole kingdom of France, I would not take a second shock." Allamand states that when he himself took the shock "he lost the use of his breath for some

minutes, and then felt so intense a pain along his right arm that he feared permanent injury from it."

In his "Cours Elémentaire de Physique," Musschenbroek describes one of the peculiar electrical machines then being constructed by the well-known London instrument maker, George Adams, and a cut of it can be seen at p. 353, Vol. I. of the translation made by Sigaud de la Fond at Paris during 1769. Another of Adams' machines is described and illustrated at p. 126 of the French translation of Cavallo's "Complete Treatise," published at Paris in 1785.

The invention of the Leyden jar is claimed with equal pertinacity for Kleist, Musschenbroek and Cunæus. While it is necessarily conceded that Von Kleist first published his discovery, it cannot be denied that his explanation of it is so obscure as, for the time, to have been of no practical use to others. It is stated by Priestley: "Notwithstanding Mr. Kleist immediately communicated an account of this famous experiment (which indeed it is evident he has but imperfectly described) to Mr. Winckler, at Leipzig, Mr. Swiettiki, of Denmark, Mr. Kruger, of Halle, and to the professors of the Academy of Lignitz, as well as to Dr. Lieberkühn, of Berlin, above mentioned, they all returned him word that the experiment did not succeed with them. Mr. Gralath, of Dantzig, was the first with whom it answered; but this was not till after several fruitless trials, and after receiving further instructions from the inventor. The Abbé Nollet had information of this discovery, and, in consequence of it says, in a letter to Mr. Samuel Wolfe, of the Society of Dantzig, dated March 9, 1746, that the experiment at Leyden was upon principles similar to that made with a phial half full of water and a nail dipped in it; and that this discovery would have been called the Dantzig experiment if it had not happened to have got the name of that of Leyden."

In the thirty-eighth volume of the *Philosophical Transactions*, No. 432, p. 297, is given an abstract of a letter (dated Utrecht, January 15, 1733, O. S.), from Petrus Van Musschenbroek, M.D., F.R.S., to Dr. J. T. Desaguliers, concerning experiments made on the Indian Magnetic Sand, chiefly gathered along the seashore in Persia. After detailing his many observations, Van Musschenbroek asks: "And, now, what can this *sand* be? Is it an imperfect magnet, or Subtile Powder of it, which, when it is grown up into a greater lump, makes the vulgar Loadstones? So I conjectured at first; but when I found by experience that common Loadstones, exposed to the fire, according to some of the methods abovemention'd, did rather lose of their force than gain, I alter'd my opinion; and now confess that I have not yet penetrated into the knowledge of the nature of this matter."

References.—Dalibard, "Histoire Abrégée," p. 33; *Dantzig Memoirs*, Vol. I. pp. 407, 409, 411; Johann Gottlob Kruger, "Dissert. de Elect," Helmstadt, 1756 (Poggendorff, I. p. 1323); Priestley, 1777, "The Hist. and Pres. State of Electricity," pp. 82–84; Opuscoli Scelti, 4to, xviii, 55; Pierre Massuet, "Essais," Leide, 1751; Musschenbroek's "Epitome elementorum," etc., 1726, "Tentamina Experimentorum Naturalium," 1731, and his "Disertatio Physica experimentalis de Magnete," as well as his "Elementa Physicæ," 1734, and the "Introductio ad Philosophiam Naturalem," 1762, the last-named two works being greatly amplified editions of the "Epitome." For Musschenbroek—Musschenbrock—consult also *Phil. Trans.*, Vol. XXXII. p. 370; Vol. XXXVII. pp. 357, 408, also the following abridgments: Baddam, 1745, Vol. VIII. p. 42; Reid and Gray, Vol. VI. p. 161 (Musschenbroek to Desaguliers); Hutton, Vol. VII. pp. 105, 647 (magnetic sand); Eames and Martyn, Vol. VI. part ii. p. 255; John Martyn, Vol. VIII. p. 737 (magnetic sand). For this magnetic sand, consult also Mr. Butterfield's article in *Phil. Trans.* for 1698, p. 336 and in the abridgments of Hutton, Vol. IV. p. 310.

A.D. 1745.—Watson (William), M.D., F.R.S., an eminent English scientist, bears "the most distinguished name in this period of the history of electricity." His first letters, treating of this science, are addressed to the Royal Society between March 28 and October 24, 1745, and, on the 6th of February and the 30th of October, 1746, he communicated other similar papers to the same Society, all which, like his subsequent treatises, are to be found in the *Philosophical Transactions*.

Dr. Watson, like most scientists at the time, made numerous experiments with the Leyden jar, and he was the first to observe the flash of light attending its discharge. He says: "When the phial is well electrified, and you apply your hand thereto, you see the fire flash from the outside of the glass wherever you touch it, and it crackles in your hand." It is to him that we owe the double coating of the jar, as well as the *plus* and *minus* of electricity.

He also shows conclusively that glass globes and tubes do not possess in themselves the electrical power, but only serve "as the first movers or determiners of that power," and he also proves that the electric fluid takes the shortest course, passing through the substance of the best medium of connection and not along its surface. This, he demonstrated by discharging a phial through a wire covered with a mixture of wax and resin.

In order to ascertain the velocity of the electric fluid from the Leyden phial and the distance at which it could be transmitted (John Wood, at A.D. 1726), Watson directed a series of experiments upon a very grand scale, with the assistance of Martin Folkes, President of the Royal Society, Lord Charles Cavendish, Dr. Bevis, Mr. Graham, Dr. Birch, Peter Daval and Messrs. Trembley, Ellicott, Robins and Short. On the 14th and 18th of July, 1747, they experimented upon a wire carrying the electricity from the Thames

bank at Lambeth to the opposite bank at Westminster, across Westminster Bridge, and, on the 24th of July, at the New River, Stoke Newington, they sent a shock through 800 feet of water and 2000 feet of land, as well as through 2800 feet of land and 8000 feet of water. Other experiments followed on the 28th of July and the 5th of August, as well as on the 14th of August of the same year, proving the instantaneous transmission of the fluid; while a year later, August 5, 1748, additional observations were made, through 12,276 feet of wire, at Shooter's Hill, showing again that the time occupied in the passage of the electricity was "altogether inappreciable." Regarding these experiments, Prof. Musschenbroek wrote to Dr. Watson, "*Magnificentissimis tuis experimentis superasti conatus omnium.*"

Watson's experiments were repeated, notably by Franklin, across the Schuylkill at Philadelphia, in 1748; by Deluc, across the Lake of Geneva, in 1749; and by Winckler, at Leipzig, in 1750. It is said that Lemonnier (A.D. 1746) produced shocks at Paris through 12,789 feet of wire and that Bétancourt (A.D. 1795) discharged electric jars through a distance of twenty-six miles.

To Dr. Watson is also due the first demonstration of the passage of electricity through a vacuum. Noad tells us that he caused the spark from his conductor to pass in the form of coruscations of a bright silver hue through an exhausted tube three feet in length, and he discharged a jar through a vacuum interval of ten inches in the form of "a mass of very bright embodied fire." These demonstrations were repeated and varied by Canton, Smeaton and Wilson.

His experiments in firing gunpowder, hydrogen, etc., by the electric spark, are detailed at p. 78 of Priestley's "History," etc., London, 1775.

Watson was rewarded with the Copley medal for his researches in electricity, which brought him also honorary degrees from two German universities. He was knighted in 1786, one year before his death.

REFERENCES.—"Watson's Experiments and Observations on Electricity," 1745, also his "Account of the Experiments made by some gentlemen of the Royal Society," etc., 1748; *Phil. Trans.*, Vol. XLIII. p. 481; Vol. XLIV. pp. 41, 388, 695, 704; Vol. XLV. pp. 49–120, 491–496; Vol. XLVI. p. 348; Vol. XLVII. pp. 202, 236, 362, 567; Vol. XLVIII. p. 765; Vol. LI. p. 394 (lyncurium of the ancients); Vol. LIII. p. 10; also the following abridgments: Hutton, Vol. IX. pp. 151, 195, 308, 368, 408, 410, 440, 553; Vol. X. pp. 12, 189, 197, 227, 233, 242, 303, 372–379, 525; Vol. XI. p. 419 (lyncurium of the ancients), 580, 660, 679; Vol. XII. p. 127; John Martyn, Vol. X. part ii. pp. 279–280, 290, 294, 329, 339, 347, 368, 407, 410. See likewise, *Scientific American Supplement* of Oct. 5, 1889, No. 718, pp. 11, 471, for an interesting engraving of Dr. Watson's experiment made through the water of the Thames, as

well as for a detailed account of Lemonnier's experiment above referred to. For Mr. A. Trembley, consult *Phil. Trans.*, Vol. XLIV. p. 58, and John Martyn's abridgments, Vol. X. part ii. p. 321.

A.D. 1746.—Lemonnier (Pierre Claude Charles), a distinguished savant, who was member of the French Academy as adjunct geometrician before he had attained his twenty-first year and became foreign member of the English Royal Society three years later, was the first scientist who drew electricity from the narrow domain of the laboratory.

He confirmed the result previously obtained by Grey (A.D. 1720) that electric attraction is not proportioned to the mass or quantity of matter in bodies, but only to the extent of their surface, length having greater effect than breadth (*Phil. Trans.*, Vol. XLIV for 1746, p. 290; Snow Harris, "Treatise on Frict. Elect.," London, 1867, p. 239, and "Hist. de l'Acad.," 1746). He found that an anvil weighing two hundred pounds gives but an inconsiderable spark, while the spark from a tin speaking-trumpet eight or nine feet long, but weighing only ten pounds, is almost equal to the shock of the Leyden phial. A solid ball of lead, four inches in diameter, gives a spark of the same force as that obtained from a thin piece of lead of like superficies bent in the form of a hoop. He took a thin and long piece of lead, and noticed that when it was electrified in its whole length it gave a very strong spark, but a very small one when it was rolled into a lump (*Ac. Par.*, 1746, M. p. 369). It had likewise been shown by Le Roi and D'Arcy that a hollow sphere accepted the same charge when empty as when filled with mercury, which latter increased its weight sixtyfold; all proving the influence of *surface* as distinguished from that of *mass* (Tyndall, Notes on Lecture IV).

Lemonnier discovered that electricity is ever present in the atmosphere, that it daily increases in quantity from sunrise till about three or four o'clock in the afternoon, diminishing till the fall of dew, when it once more increases for a while, and finally diminishes again before midnight, when it becomes insensible. He observed a continual diminution of electricity as the rain began to fall, and he says: "When the wire was surrounded with drops of rain, it was observed that only some of them were electrical, which was remarkable by the conic figure they had; whilst the others remained round as before. It was also perceived that the electrical and non-electrical drops succeeded almost alternately; this made us call to mind a very singular phenomenon which happened some years before, to five peasants who were passing through a cornfield, near Frankfort upon the Oder, during a thunder-storm; when the lightning killed the first the third and the fifth of

them, without injuring the second or the fourth" (*Phil. Trans.*, Vol. XLVII. p. 550).

References.—Le Monnier, "Lois du Magnétisme," Paris, 1776–1778; *Phil. Trans.*, Vol. XLIV. p. 247; Vol. XLVIII. part i. p. 203; "Journal des Sçavans," Vol. CXII for 1737, p. 73; also Hutton's abridgments, Vol. IX. pp. 275, 308, 368, 591 (biogr.); John Martyn's abridgments, Vol. X. part ii. pp. 329–348; "Philosophical Magazine," Vol. VI. for 1800, p. 181, "Some Account of the Late P. C. Le Monnier," 1715–1799; "Mémoires de l'Institut Nat. des Sc. et des Arts," Hist. An. IX. p. 101; *Mémoires de l'Acad. Royale des Sciences*, 1746, pp. 14–24, 447, 671–696; 1752, Tome I. pp. 9–17, Tome II. 233–243, 346–362; 1770, p. 459; Bertholon, "Elec. du Corps Humain," 1786, Vol. I. pp. 10–14; Harris, "Frict. Elec.," p. 239; *Sc. American Supplement*, for Oct. 5, 1889, No. 718, pp. 11, 471. See also reports of the experiments of G. B. Beccaria, G. F. Gardini ("De inflexu," etc., ss. 50, 51), Andrew Crosse and others at "Bibl. Britan. Sc. et Arts," 1814, Vol. LVI. p. 524.

A.D. 1746.—Bevis (John), English astronomer and Secretary of the Royal Society, first suggested to Dr. Watson the external coating of the Leyden jar with tinfoil or sheet-lead, and was likewise the first to observe that the force of the charge increases as larger jars are employed, but not in proportion to the quantity of water they contain. As water only played the part of a conductor, he rightly thought that metal would do equally well, and he therefore filled three jars with leaden shot instead of with water. When the metallic connection was made it was found that the discharge from three jars was greater than that from two and the discharge from two much greater than that from one. This showed that the seat of the electric force is the surface of the metal and the glass, and proves that the force of the charge is in proportion to the quantity of coated surface.

Thus to Dr. Bevis belongs the credit of having constructed the first electric battery, although the honour has been claimed by the friends of Daniel Gralath (A.D. 1747).

References.—*Phil. Trans.*, abridged, Vol. X. pp. 374, 377; Wilson, "Treatise," London, 1752, Prop. XVII. p. 107.

A.D. 1746.—Le Cat (Claude Nicolas), a physician of Rouen, observed, when suspending several pieces of leaf gold at his conductor, that they hung at different distances according to their sizes, the smallest pieces placing themselves nearest the conductor and the largest farthest from it.

Le Cat (1700–1768) became celebrated for his surgical operations and succeeded in carrying off all the first prizes offered by the Royal Academy of Surgeons between the years 1734 and 1738 inclusively. Consult his different works named at p. 292 of Ronalds'

"Catalogue"; "Histoire de l'Electricité," pp. 84 and 85; "Biographie Générale," Vol. XXX. pp. 179–182.

A.D. 1746.—Maimbray (M.), of Edinburgh, electrified two myrtle trees, during the entire month of October 1746, and found that they put forth small branches and blossoms sooner than other shrubs of the same kind which had not been electrified. This result was confirmed by the Abbé Nollet, who filled two pots with vegetating seeds and found that the pot which he had constantly electrified for fifteen consecutive days put forth earlier sprouts as well as more numerous and longer shoots than did the other.

Like experiments were at the same time carried on with equal success by M. Jallabert and M. Boze, as well as by the Abbé Menon, Principal of the College of Bueil at Angers, France. The last named also found that electricity increases the insensible perspiration of animals. He chose cats, pigeons and chaffinches, and observed after they were electrified, that one cat was sixty-five or seventy grains lighter than the other, the pigeon from thirty-five to thirty-eight grains, and the chaffinch had lost six or seven grains. He also electrified a young person between the ages of twenty and thirty, for five hours and found a loss in weight of several ounces.

With reference to the effect of electricity on different varieties of growing plants, a paper in Boston not long ago published the following:

"In the last few years some very interesting experiments in gardening by electricity have been made by Prof. Selim Lemström, of the University of Helsingfors. These have been carried out both upon the potted plants in the hot-house and upon plants in the open field, the insulated wires in the latter case being stretched upon poles over the plot of ground, and provided with a point for each square metre of area. The current has been supplied by Holtz machines run from eight to eighteen hours daily, the positive pole being connected with the network of wires and the negative with a zinc plate buried in the ground. The electric influence was scarcely perceptible in the growing plants, but was very marked in the yield of many species, especially of barley and wheat, of which the crop was increased by half in some cases. In the hot-house the maturity of strawberries was greatly advanced. The results have shown that plants may be divided into two groups: one, the development of which is favoured by electricity, comprising wheat, rye, barley, oats, red and white beets, parsnips, potatoes, celeriac, beans, raspberries, strawberries and leeks; and the other, whose development is more or less interfered with by electricity, including

peas, carrots, kohlrabi, rutabagas, turnips, white cabbages and tobacco. The more fertile the soil, and consequently the more vigorous the vegetation, the greater has been the excess of the crop under electric influence. Prof. Lemström's experiments up to 1887 were carried on in Finland, but he has since repeated his work in France, and demonstrated that the electric influence is the same in any climate, though likely to be injurious under a scorching sun."

References.—Nollet, "Recherches sur l'Electricité," pp. 366, 382; *Phil. Trans.*, abridged, Vol. X. p. 384; *Electrical Review*, London, June 5, 1891, p. 707.

A.D. 1746.—Knight (Gowan or Gowin), F.R.S., an English physician, is the first to make very powerful steel magnets. The method, which he long succeeded in keeping secret, was described after his death, in the *Phil. Trans.* for 1746–1747, Vol. XLIV. It consists of placing two magnets in the same straight line, with their opposite poles close to or very near each other, and in laying under them the bar to be magnetized after having it tempered at a cherry-red heat. The magnets are then drawn apart in opposite directions along the bar, so that the south pole of one magnet passes over the north polar half, and the north pole of the other magnet passes over the south polar half of the bar.

This was how Dr. Knight made the bars of the two great magnets of the Royal Society. Each magnet contained two hundred and forty bars, fifteen inches long, one inch wide and half an inch thick. Dr. Robison described, in 1800, the effect of pressing together the dissimilar poles of the two magnets, and, thirty years later, Prof. Faraday, upon placing a soft iron cylinder, one foot long and three-quarters of an inch in diameter, across the dissimilar poles, found that he required a force of one hundred pounds to break down the attractive power.

Previously to Dr. Knight's discovery, the method of making artificial magnets most in use was by simply rubbing the bar to be magnetized upon one of the poles of a natural magnet in a plane at right angles to the line joining its two poles.

Another secret of Dr. Knight was also, after his death, made known to the Royal Society by its secretary, Mr. Benjamin Wilson. It was the mode of making artificial paste magnets. He collected a large quantity of iron filings, which he cleansed and made into a fine powder under water and afterward dried and mixed, preferably with linseed oil. This was baked into cakes, which were magnetized by placing them between the ends of his magazine of artificial magnets.

To Dr. Knight was given the first English patent in the Class of

Electricity and Magnetism. It bears date June 10, 1766, No. 850, and is for the construction of "Compasses so as to prevent them being affected by the motion of the ship," etc.

REFERENCES.—*Phil. Trans.*, Vol. XLIII. pp. 161, 361; Vol. XLIV. p. 656; Vol. XLIX. p. 51; Vol. LXVI. p. 591; C. R. Weld, "Hist. of Roy. Soc.," Vol. I. p. 511; Noad, "Manual," 1859, p. 593; Sturgeon, "Sc. Researches," Bury, 1850, p. 249; also the abridgments by Hutton, Vol. IX. pp. 71, 74, 122, 390 (Folkes), 653; Vol. X. pp. 64, 67; Vol. XIV. pp. 117, 480; and by John Martyn, Vol. X. part ii. pp. 678–698.

A.D. 1746.—Gravesande (Wilhelm Jacob), celebrated Dutch mathematician and natural philosopher (1688–1742), whose family name was Storen Van 'Sgravesande, is the author of "Eléments de physique démontrés mathématiquement. . . . ou introduction à la philosophie Newtonienne," which was translated from the Latin and published at Leyden in 1746.

At p. 87 of the second volume of the last-named work he gives a description of an electrical machine constructed on the plan of that of Hauksbee. It consisted merely of a crystal globe, which was mounted upon a copper stand, and against which was pressed the hand of the operator while it was made to revolve rapidly by means of a large wheel.

Gravesande taught publicly on the Continent the philosophy of Newton, and, by so doing, was one of the first to bring about a revolution in the domain of physical sciences generally. His original "Physices Elementa Mathematica," as well as his "Philosophiæ Newtonianæ," etc., and "Introductio ad Philosophiam," etc., were respectively published at Leyden in 1720, 1723 and 1736.

REFERENCE.—Houzeau et Lancaster, "Bibl. Générale," Vol. II. p. 252.

A.D. 1746.—Nollet (Jean Antoine), a distinguished French philosopher (1700–1770), to whom was given the title of Abbé while holding deacon's orders, is the first in France to make experiments with the Leyden jar.

While in Paris he applied himself to electrical studies in company with Charles Dufay (already noticed at A.D. 1733), and made such ingenious experiments that René de Réaumur allowed him the free use of his extensive apparatus and laboratory. During the month of April 1746, he transmitted, in the presence of the French King, an electrical shock from a small phial through a chain of one hundred and eighty of the Royal Guards, and at the Carthusian Convent, not long afterward, he sent a shock through a line of monks stretched a distance of over a mile, causing them all to experience instantaneously the same sensation.

Nollet's work, "Essai sur l'électricité des corps," was originally

published at Paris in 1746. He was the first to observe that pointed bodies electrified give out streams of light (the smallest points displaying "brushes of electric light"), but that they do not exhibit as powerful indications of electricity as are shown by blunt bodies. He also found that glass and other non-conductors are more strongly excited in air than *in vacuo;* that the electric spark is more diffuse and unbroken *in vacuo;* and that an excited tube loses none of its electricity by being placed in the focus of a concave mirror when the sunlight is therein concentrated.

His experiments upon the evaporation of fluids by electricity, as well as upon the electrification of capillary tubes full of water (observed also by Boze), and upon the electrification of plants and animals, are detailed in his "Recherches," etc., pp. 327, 351, 354–356, while his observations upon the electrical powers of different kinds of glass are given in the sixth volume of the "Leçons de Physique Expérimentale," issued in 1764.

As has been truly said, it is no easy matter to form an adequate idea of Nollet's theory of electricity, which was opposed at the time by almost all the eminent electrical philosophers of Europe. He asserted that when an electric is excited, electricity flows to it from all quarters, and when it is thus *affluent,* it drives light bodies before it. Hence the reason why excited bodies attract. When the electricity is *effluent* the light bodies are of course driven from the electric, which in that condition appears to repel. He therefore believed every electric to be possessed of two different kinds of pores, one for the emission of the electric matter, and the other for its reception.

Nollet is the first one who published the close relationship existing between lightning and the electric spark. This he did during the year 1748, in the fourth volume of his "Leçons," already alluded to and from which the following is extracted: "If any one should undertake to prove, as a clear consequence of the phenomenon, that thunder is in the hands of nature what electricity is in ours—that those wonders which we dispose at our pleasure are only imitations on a small scale of those grand effects which terrify us, and that both depend on the same mechanical agents . . . I confess that this idea, well supported, would please me much. . . . The universality of the electric matter, the readiness of its actions, its instrumentality and its activity in giving fire to other bodies, its property of striking bodies, externally and internally, even to their smallest parts . . . begin to make me believe that one might, by taking electricity for the model, form to one's self, in regard to thunder and lightning, more perfect and more probable ideas than hitherto proposed."

For a memoir treating of the cause of thunder and lightning, written by the Rev. Father de Lozeran de Fech, of Perpignan, the Bordeaux Academy of Sciences had in 1726 awarded him its annual prize; and the same institution conferred a similar award, in August 1750, upon M. Bergeret, a physician of Dijon, whose memoir admitted the close analogy between lightning and electricity.

References.—Ronalds' "Catalogue," pp. 369–371; Jean Morin, "Réplique," Paris, 1749; A. H. Paulian, "Conjectures," 1868; "Abrégé des transactions philosophiques," Vol. X. p. 336; "Mémoires de mathématique," etc., pour 1746, p. 22; "Journal des Sçavans," Vol. CXVII. for 1739, pp. 111–115, and Vol. CXLII for 1747, pp. 248–265; "Medical Electricity," by Dr. H. Lewis Jones, Philad., 1904, p. 2; "Mémoires de l'Acad. Royale des Sciences" pour 1745, p. 107; 1746, p. 1; 1747, pp. 24, 102, 149, 207; 1748, p. 164; 1749, p. 444; 1753, pp. 429, 475; 1755, p. 293; 1761, p. 244; 1762, pp. 137, 270; 1764, pp. 408–409; 1766, p. 323; "Leçons," eighth edition, Vol. IV. p. 315; *Phil. Trans.*, Vol. XLV. p. 187; Vol. XLVI. p. 368; Vol. XLVII. p. 553; also the following abridgments: Hutton, Vol. X. pp. 20, 295, 372–379, 446 (Dr. Birch); Vol. XI. p. 580; John Martyn, Vol. X. part ii. pp. 277–333, 382 (Folkes), 414. See the experiments of Etienne François du Tour, "Sur la manière dont la flamme agit sur les corps electriques," in a letter addressed by him to Nollet in 1745, and in "Mém. de Mathém. et Phys.," Vol. II. p. 246, Paris, 1755; also Zantedeschi and Faraday on the "Magnetic Condition of Flame" (Faraday's "Exper. Res.," Vol. III. pp. 490–493).

A.D. 1746.—Wilson (Benjamin) (1721–1788), Secretary to the Royal Society, writes his "Essay toward an explication of the phenomena of Electricity deduced from the ether of Sir Isaac Newton." In the chapter of Priestley's "History" treating of the Theories of Electricity, he says: "With some, and particularly Mr. Wilson, the chief agent in all electrical operations is Sir Isaac Newton's ether, which is more or less dense in all bodies in proportion to the smallness of their pores, except that it is much denser in sulphureous and unctuous bodies. To this ether are ascribed the principal phenomena of attraction and repulsion, whereas the light, the smell, and other sensible qualities of the electric fluid are referred to the grosser particles of bodies, driven from them by the forcible action of this ether. Many phenomena in electricity are also attempted to be explained by means of a subtile medium, at the surface of all bodies, which is the cause of the refraction and reflection of the rays of light, and also resist the entrance and exit of this ether. This medium, he says, extends to a small distance from the body, and is of the same nature with what is called the electric fluid.[1] On the surface of conductors this medium is rare

[1] Just here we may refer to the fact—for it is a fact—that the electrical energy transmitted over a line, which may be many miles in length, really does not travel by the wire connecting the two points. It travels in the ether surrounding the wire. The wire itself is, in fact, the guiding core of the disturbances in the ether which proceed outward in all directions to unlimited

and easily admits the passage of the electric fluid, whereas on the surface of electrics it is dense and resists it. This medium is rarefied by heat, which converts non-conductors into conductors."

At pp. 71 and 88, 1746 edition, and at p. 88, Prop. XI. of the 1752 edition of this same "Essay," Wilson says that during the year 1746 he discovered a method of giving the shock of the Leyden jar to any particular part of the body without affecting any other portion; that he increased the shock from the jar by plunging it into water, thereby giving it a coating of water on the outside as high as it was filled on the inside; and that the accumulation of electricity in the Leyden jar is always in proportion to the thinness of the glass, the surface of the glass and that of the non-electrics in contact with the inside and outside thereof.

It was in this same year, 1746, that Wilson first observed the *lateral shock* or *return stroke*, which was not, however, explained until Lord Mahon, third Earl of Stanhope, published his "Principles of Electricity," in 1779.

On the 13th of November, 1760, a paper of Mr. Wilson's was read before the Royal Society, in which he detailed several of his ingenious experiments on the *plus* and *minus* of electricity, and showed that these can be produced at pleasure by carefully attending to the form of bodies, their sudden or gradual removal and the degrees of electrifying. He had previously noticed that when two electrics are rubbed together, the body whose substance is hardest and electric power strongest is always electrified positively and the other negatively. Rubbing the tourmaline and amber together he produced a *plus* electricity on both sides of the stone and a *minus* on the amber; but, rubbing the diamond and the tourmaline, both sides of the tourmaline were electrified *minus* and the diamond *plus*. When insulated silver and glass were rubbed, the silver became *minus* and the glass *plus*.

He further observed that when directing a stream of air against a tourmaline, a pane of glass or a piece of amber, these were electrified *plus* on both sides. Prof. Faraday subsequently showed that no electrical effect is produced in these cases unless the air is either damp or holds dry powders in suspension, the electricity being produced

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distances. The guiding core or conducting wire is needed to focalize or direct the delivery of the energy. This curious conclusion of science, then, that the power from the power-station wire travels in the space around the wires led from the station, is one of the results of recent electrical studies, just as with light those studies begun by Maxwell and Hertz have led to the inevitable conclusion that the light of the candle, the light of a kerosene lamp, and the light of a gas burner are all in essence electrical phenomena, as are all forms of radiation in the ether ("Electricity During the Nineteenth Century," Prof. Elihu Thomson, Washington, 1901).

by the friction of particles of water in the one case and by the particles of powder in the other. Sir David Brewster, who thus mentions the latter fact, likewise singles out two more of Mr. Wilson's observations, viz. that when a stick of sealing-wax is broken across or when a dry, warm piece of wood is rent asunder, one of the separated surfaces becomes vitreously and the other resinously electrified.

REFERENCES.—De La Rive, "Electricity," Vol. I. p. 203; Wilson, "Treatise on Electricity"; Wilson and Hoadley, "Observations on a Series of Electrical Experiments"; *Phil. Trans.*, Vol. XLVIII. p. 347; Vol. XLIX. p. 682; Vol. LI. part i. pp. 83, 308, 331, part ii. p. 896; Vol. LIII. pp. 436, etc.; Vol. LXVIII. p. 999; Vol. LXIX. p. 51; also Hutton's abridgments: Vol. X. p. 420; Vol. XI. pp. 15, 396, 504; Vol. XII. pp. 44, 147; Vol. XIII. p. 374; Vol. XIV. pp. 334, 337, 458, 480; "The Electrical Researches of the Hon. Henry Cavendish," Cambridge, 1879, No. 125; L. E. Kaemtz, "Lehrbuch der Meteor," Halle, 1832, Vol. II. p. 395.

A.D. 1746.—Ellicott (John), of Chester, suggests a method of estimating the exact force of the electric charge contained in the Leyden jar by its power to raise a weight in one scale of a balance while the other scale is held over and attracted by the electrified body. This was the principle upon which Mr. Gralath constructed the electrometer shown in *Dantzig Memoirs*, Vol. I. p. 525.

With reference to the experiments of Boze (A.D. 1738) and of Nollet (A.D. 1746) made with capillary tubes, he says that the siphon, though electrified, will only deliver the water by drops if the basin containing the water is also electrified. He explains Nollet's observation, that the electric matter issues more sensibly from the point at the extremity of the conductor, by saying that the effluvia, in rushing from the globe along the conductor, as they approach the point are brought nearer together, and therefore are denser there, and if the light be owing to the density and velocity of the effluvia it will be visible at the point and nowhere else. Ellicott's theory of electricity is founded upon the following data: (1) electrical phenomena are produced by effluvia; (2) these effluvia repel each other; (3) they are attracted by all other matter. If the word *fluid* is substituted for effluvia, these data absolutely agree with those adopted by Æpinus and Cavendish, forming the basis of the only satisfactory theory of electricity hitherto proposed.

REFERENCES.—Boulanger, "Traité de la Cause et des phénomènes de l'électricité," Paris, 1750, p. 324; *Phil. Trans.* for 1746, Vol. XLIV. p. 96, and for 1748, Vol. XLV. pp. 195–224, 313; also the abridgments of John Martyn, Vol. X. part ii. pp. 324, 386, 389, 394; Hutton, Vol. IX. p. 475.

A.D. 1747.—Pivati (Johannes Francisco), a Venetian physician, relates in his "Lettere della elettricita medica," that if odorous

substances are confined in glass vessels and the latter excited, the odours and other medical virtues will transpire through the glass, infect the atmosphere of a conductor, and communicate the virtue they may possess to all persons in contact therewith; also, that those substances held in the hands of persons electrified will communicate their virtue to them so that medicines can thus be made to operate without being taken in the usual manner.

This appears to have been likewise asserted especially by M. Veratti, of Bologna, and by M. Bianchi, of Turin; also by Prof. Winckler, of Leipzig, who satisfied himself of the power of electricity on sulphur, cinnamon, and on balsam of Peru even at a distance.

By the above-named means of applying the electric fluid Pivati is reported to have effected cures of ordinary pains and aches, and to have even relieved of gout the old Bishop Donadoni, of Sebenico, who had long been a sufferer, and who was at the time seventy-five years of age. This pretended transudation and its medical effects could not, however, be verified, even with the directions asked of and given by Prof. Winckler, when very careful and exhaustive experiments were made, on the 12th of June, 1751, at the house of Dr. Watson, in presence of the president and other officers as well as friends of the Royal Society. Nor could Dr. Bianchini, Professor of Medicine at Venice, succeed any better. At a later date, Franklin asserted that it was impossible to combine the virtues of medicines with the electric fluid.

References.—Franklin's Letters, p. 82; *Phil. Trans.* for 1748, Vol. XLV. pp. 262, 270; for 1750, Vol. XLVI. pp. 348, 368; for 1751, Vol. XLVII. p. 231; for 1753, Vol. XLVIII. pp. 399, 406, and Vol. X. abridged, pp. 400–403.

A.D. 1747.—Louis (Antoine), eminent French surgeon (1723–1792), publishes "Observations sur l'électricité," of which the first issue appeared in 1747 and wherein he indicates the employment of electricity in medical practice. This he did again in his "Recueils," upon a more pretentious scale, six years later, 1753.

References.—N. F. J. Eloy, "Dict. de la Médecine," Mons, 1778, Vol. III. p. 206; "Gen. Biog. Dict." of Alex. Chalmers, 1815, Vol. XX. p. 419; Hœfer, "Nouv. Biog. Gén.," Vol. XXXI. p. 1033; Quérard, "La France Littéraire"; "Biog. Univ.," de Michaud, Vol. XXV. pp. 319–325.

A.D. 1747.—Gralath (Daniel) publishes in the *Dantzig Memoirs* his "Geschichte der Electricität."

He is the first to construct a Leyden phial with a long, narrow neck, through which is passed an iron wire bearing a tin knob in place of the iron nail theretofore used; and, with several of these

phials joined together in the form of a battery, he had, during the previous year, transmitted a shock through a chain of twenty persons. His observations are recorded in the above-named *Memoirs* at pp. 175–304 and 506–534, Vol. I.; pp. 355–460, Vol. II.; pp. 492–556, Vol. III. Gralath's "Electrische Bibliothek" is in Vols. II. and III.

A.D. 1747.—The Swedish mathematician and philosopher, Samuel Klingenstierna, and his pupil, M. Stroemer, were the first who properly electrified by the rubber, and their experiments were published in the Acts of the Royal Academy of Sciences at Stockholm for the year 1747 (see Priestley's "History of Electricity," Part I. period viii. s. 3, wherein he alludes to Wilcke's "Herrn Franklin's briefe," etc., p. 112).

A.D. 1748.—Morin (Jean), French physicist, publishes at Chartres "Nouvelle dissertation sur l'électricité des corps," etc., in which he details many of his experiments, and endeavours to give a correct explanation of all the extraordinary electrical phenomena hitherto observed. He is also the author of a "Reply to Mr. Nollet upon Electricity," published in 1749 at Chartres and at Paris, as well as of a treatise upon Universal Mechanism, which latter, according to the *Journal des Savants*, contained more information upon Nature generally, and expressed in fewer words, than was embraced in any previous work.

References.—"Dict. Univ.," Vol. XI. p. 568; "Biog. Générale," Vol. XXXVI. p. 599.

A.D. 1749.—Stukeley (the Rev. William), M.D., is the first who advanced that earthquakes are probably caused by electricity. This he did in a paper read before the Royal Society, March 22, 1749, having reference to the subterranean disturbances noticed in London, February 8 and March 8 of the same year. In this communication, as well as in a subsequent one read to the same Society, December 6, 1750, bearing upon a similar disturbance observed throughout England during the previous month of September, he explains why earthquakes are not the result of subterraneous winds, fires, vapours, etc.

One of his strongest arguments is that no such vapours could instantaneously have destroyed thirteen great cities as did the earthquake which occurred in Asia Minor, A.D. 17, and which is reckoned to have shaken a cone of earth three hundred miles diameter in base and two hundred miles in the axis. This quantity of earth, he says, "all the gunpowder which has ever been made since the invention of it would not have been able to stir, much less

any vapours, which could be supposed to be generated so far below the surface," and, he adds, "if the concussion depended upon a subterraneous eruption the shock would precede the noise."

He observes that the earth for months prior to the afore-named disturbances "must have been in a state of electricity ready for that particular vibration in which electrification exists"; that all the vegetation had been "uncommonly forward . . . and electricity is well known to quicken vegetation"; that the aurora borealis had been very frequent about the same time and had been twice repeated just before the earthquake, "of such colours as had never been seen before," there being, one evening, "a deep red aurora borealis covering the cope of heaven very terrible to behold"; that the whole year had been "remarkable for fire-balls, thunder, lightning and coruscations, almost throughout all England," all which "are rightly judged to proceed from the electrical state of the atmosphere"; and, finally, that, a little before the earthquake, "a large and black cloud suddenly covered the atmosphere, which probably occasioned the shock by the discharge of a shower." He adds that, according to Dr. Childrey, earthquakes are always preceded by rain and sudden tempests of rain in times of great drought.

Dr. Stephen Hales (1677–1761), who was Stukeley's classmate at Bennet College, Cambridge, and later his chief assistant in the study of the natural sciences, and who afterward became celebrated for his physical investigations and discoveries, arrives at a like conclusion. He thinks that "the electric appearances were only occasioned by the great agitation which the electric fluid was put into by the shock of so great a mass of the earth." The great noise which attended the disturbance of March 8, 1749, he conjectured was "owing to the rushing or sudden expansion of the electric fluid at the top of St. Martin's spire, where all the electric effluvia, which ascended along the large body of the tower, being strongly condensed, and accelerated at the point of the weather-cock, as they rushed off made so much the louder expansive explosion." It may be added here that Dr. Hales is the one who, at a previous date, had communicated to the Royal Society his observation of the fact that the electric spark proceeding from warm iron is of a bright, light colour, while that from warm copper is green, and the colour from a warm egg of a light yellow. In his opinion, these experiments appeared to argue that some particles of those different bodies are carried off in the electric flashes wherein those different colours are exhibited.

For Stephen Hales, consult the *Phil. Trans.*, Vol. XLV. p. 409, as well as the abridgments of Hutton, Vol. IX. p. 534, and for his

portrait see "Essays in Historical Chemistry," by T. E. Thorpe, London, 1894.

For Stukeley and for Stephen Hales: consult "General Biographical Dictionary," Alex. Chalmers, London, 1814, Vol. XVII. pp. 41–43.

References.—Priestley, "History of Electricity," Part I. period x. s. 12; *Phil. Trans.*, abridged by John Martyn, Part II. of Vol. X. pp. 406–526, 535, 540, 541, 551; Vol. XLIV–XLV, p. 409; Appendix to the *Phil. Trans.* for 1750, Vol. XLVI; Hale, "Statical Essays," II. p. 291; Thomson, "Hist. Roy. Soc.," 1812, p. 197.

A.D. 1749.—Jallabert (Jean Louis), Professor of Philosophy and Mathematics at Geneva, is the author of "Expériences sur l'électricité, avec quelques conjectures sur la cause de ses effets," of which a smaller edition had appeared at Geneva in 1748.

He confirms the result obtained by Dr. Watson (A.D. 1745) that the electric fluid takes the shortest course by passing through the substance of a conducting wire instead of along its surface. By making his Leyden experiments with a jar in which the water is frozen, he shows that ice is a conductor of electricity. He improves upon Nollet's experiments, and demonstrates conclusively that plants which are electrified grow faster and have finer stems, etc., than those not electrified. He is the first to observe that a body pointed at one end and round at the other produces different appearances upon the same body, according as the pointed or the rounded end is presented to it. The *Dantzig Memoirs*, Vol. II. p. 378, tell us that Carolus Augustus Van Bergen, Professor of Medicine at Frankfort on Oder, had previously noticed, "as a small step toward discovering the effect of pointed bodies," that sparks taken from a polished body are stronger than those from a rough one. With the latter he found it difficult to fire spirits, but he could easily do it with a polished conductor.

M. Jallabert is also known to have effected some medical cures through the agency of the electric fluid, as related in the "Expériences" above alluded to.

References.—"Biog. Univ.," Vol. XX. p. 535; Bertholon, "Elec. du Corps Humain," 1786, Vol. I. pp. 260, 292, 299, 334, 413, and Vol. II. p. 291; Beccaria, "Dell' Elettricismo Naturale," etc., p. 125; "Journal des Sçavans," Vol. CXLIX. for 1749, pp. 1–18, 441–461; "Medical Electricity," by Dr. H. Lewis Jones, Philad. 1904, p. 2.

A.D. 1749.—Mines are fired by electricity (S. P. Thompson, lecture delivered October 7, 1882, at the University College, Bristol).

A.D. 1749.—Through the important work entitled "Traité sur l'Electricité," Louis Elisabeth de la Vergne Tressan secures,

a year later, admission to both the French Académie des Sciences and the English Royal Society. During 1786, three years after his death, the above-named work was merged into a publication in two volumes under the title of "Essai sur le fluide électrique considéré comme agent universel."

REFERENCES.—"Biographie Générale," Vol. XLV. pp. 623–626; Larousse, "Dictionnaire Universel," Vol. XV. p. 474.

A.D. 1749.—Duhamel (Henri Louis, du Monceau) (1700–1782), member of the French Royal Academy of Sciences, develops, in conjunction with M. Antheaulme, the method introduced by Gowin Knight (A.D. 1746) for making artificial magnets, which latter process was found to be defective when applied to very large bars. To Le Maire, however, is due (*Mem. de l'Acad. de Paris*, 1745 and 1750), the notable improvement which consists in magnetizing at the same time two steel bars of any shape by placing them parallel to each other and connecting their extremities, with pieces of soft iron placed at right angles, in order to form a closed rectangular parallelogram. Two strong magnets, or two bunches of small magnetic bars, with their similar poles together, are then applied to the centre of one of the bars to be magnetized and are drawn away from each other, practically as in Dr. Knight's method, while being held at an inclination of about forty-five degrees. The operation is repeated upon the other bar and continued alternately until sufficient magnetism is imparted to both, it being borne in mind that before the treatment is given to the second bar the poles must in each instance be reversed, *i. e.* the pole which was to the right hand should be turned to the left. The entire operation is to be repeated upon the reverse side of both bars.

REFERENCES.—Harris, "Rudim. Magn.," I. and II. pp. 85 and 86; P. Larousse, "Dict. Univ.," Vol. VI. p. 1363; "Biog. Générale," Vol. XV. pp. 106–107; Condorcet, "Eloge de Duhamel"; I. M. Des Essarts, "Siècles littéraires"; Georges Cuvier, "Hist. des Sc. Naturelles," Vol. V; Thos. Thomson, "Hist of the Roy. Soc.," London, 1812, p. 45.

A.D. 1750–1753.—In M. Arago's "Historical Eloge of James Watt," translated by James P. Muirhead and published in London during the year 1839, it is said, at p. 6, that Watt constructed, at about the period first mentioned herein, a small electrical (his earliest) machine, the brilliant sparks from which became a subject of much amusement and surprise to all the companions of the poor invalid ("James Watt," by Andrew Carnegie, New York, 1905).

A.D. 1750.—Wargentin (Pierre Guillaume—Perh Vilhelm—) (1717–1783), Secretary to the Swedish Academy of Sciences and a

distinguished astronomer, addresses, on the 21st of February, a letter to the Royal Society, of which a copy is to be found in Vol. XLVII. p. 126 of the *Phil. Trans.* In this he gives his observations of the result produced on the magnetic needle by the aurora borealis.

We have already seen (under the A.D. 1683 date), that the discovery of the fact that magnets are affected by the polar lights has been ascribed to Wargentin, and we have also learned (A.D. 1722) that he ascertained the diurnal changes of the magnetic needle with more precision than had been done by George Graham.

REFERENCES.—Walker, "Magnetism," p. 116; *American Journal Science and Arts*, 1841, Vol. XXX. p. 227; Celsius, A.D. 1740, and the abridgments of Hutton, Vol. X. p. 165.

A.D. 1750.—Michell (John), an eminent English man of science, Professor at Queens' College, Cambridge, publishes "A treatise of Artificial Magnets, in which is shown an easy and expeditious method of making them superior to the best natural ones."

The process introduced by this work is known as that of the "double touch." This consists in first joining, at about a quarter of an inch distance, two bundles of strongly magnetized bars, having their opposite poles together, and in drawing these bars backward and forward upon and along the entire length of the bars to be magnetized, which latter have already been laid down end to end and in a straight line. The operation is to be repeated upon each side of the bars. The central bars of a series thus acquire at first a higher degree of magnetism than do the outer ones, but by transposing the latter and treating all alike the magnetic virtue is evenly distributed. In this process the external bars act the same part as do the pieces of soft iron employed in the Duhamel method.

At Chap. VI. p. 20 of the third volume of his "Rudimentary Magnetism," Harris thus expresses himself: "Michell advanced the idea that in all the experiments of Hauksbee, Dr. Brooke Taylor, William Whiston and Musschenbroek, the force may really be in the inverse duplicate ratio of the distances, proper allowance being made for the disturbing changes in the magnetic forces so inseparable from the nature of the experiment. He is hence led to conclude that the true law of the force is identical with that of gravity, although he does not set it down as certain."

REFERENCES.—Harris, "Rud. Mag.," I. and II. pp. 94–95; C. R. Weld, "Hist. Roy. Soc.," Vol. I. p. 512; *Phil. Trans.*, Vol. LI. pp. 390, 393, and Hutton's abridgment, Vol. XI. p. 418; Gaugain's observations in "Sc. Am. Suppl.," No. 7, p. 99.

A.D. 1750.—Boulanger—not Boullangère—(Nicholas Antoine) (1722–1759), a well-known French writer, whose extensive studies

were interrupted by his death, in 1759, at the early age of thirty-seven, gives, in this "Traité de la cause et des phénomènes de l'électricité," accounts of many important observations made in the electrical field.

His attention was carefully given to ascertaining the degrees in which different substances are capable of being excited, and he gives several lists of such, inferring therefrom that the most transparent and the most brittle are always the most electric.

At pp. 64 and 124 of the above-named "Traité" he states that electricity affects mineral waters much more sensibly than common water; that black ribbons are more readily attracted than those of other colours, next to the black being the brown and deep red; and that, of two glass cylinders exactly alike, except that one is transparent and the other slightly coloured, the transparent one will be the more readily excited.

References.—The "Traité," notably at pp. 135 and 164; "Biog. Générale," Vol. VI. p. 939; Le Bas, "Dict. Encycl. de la France"; Quérard, "La France Littéraire"; Chaudon et Delandine, "Dict. historique."[1]

A.D. 1751.—Adanson (Michael), a French naturalist of very high reputation, who, before the age of nineteen, had actually described four thousand species of the three kingdoms of nature, introduces in his "History of Senegal" the *silurus electricus*, a large species of eel originally brought from Surinam. Sir John Leslie states that the *silurus* is furnished with a very peculiar and complex nervous apparatus which has been fancifully likened to an electrical battery, and that, from a healthy specimen exhibited in London, vivid sparks were drawn in a darkened room. M. Broussonet alludes to the *silurus* as *Le Trembleur* in the "Hist. de l'Acad. Royale des Sciences" for 1782, p. 692.

Adanson also called attention, in 1756, to the electrical powers of the *malapterus electricus*, but, according to the able naturalist, James Wilson ("Ichthyology," *Encycl. Brit.*), there is a much earlier account of the fish extracted from the narrative of Baretus and Oviedo dated 1554.

The Swedish scientist, Karl A. Rudolphi, pupil of Linnæus, called the *princeps helminthologorum*, has given a detailed description as well as illustrations of the electric organs of the *malapterus* in "Ueber den Zitter-wels," *Abh. Berl. Acad.* VII. . . . This fish, which the Arabs call *Raad* or *Raash* (thunder), gives its discharge chiefly when touched on the head, but is powerless when held by the tail, the electrical organs in fact not reaching the caudal fin.

To Adanson has been attributed the authorship of an essay on

the "Electricity of the Tourmaline," Paris, 1757, which bears the name of the Duke de Noya Caraffa.

References.—Spreng, "Hist. R. Herb.," Vol. II; and "Adanson's Biog.," Vol. II. "Encycl. Britannica," Rees' "Cycl." Supplement and in "Bibl. Universelle," Vol. I; Chambers' "Encyl." for 1868, Vol. III. p. 822; Cavallo, "Nat. Phil.," Philad., 1825, Vol. II. p. 237; *Scientific American Supplement*, No. 457, pp. 7300, 7301; Rozier, Vol. XXVII. p. 139, and W. Bryant in *Trans. Am. Phil. Soc.* II. p. 166, O. S.

A.D. 1752.—Franklin (Benjamin) (1706–1790), an able American editor, philosopher and statesman, crowns his many experiments with the brilliant discovery of the identity of electricity and lightning. Humboldt says: "From this period the electric process passes from the domain of speculative physics into that of cosmical contemplation—from the recesses of the study to the freedom of nature" ("Cosmos," Vol. II. 1849, p. 727). Wall (A.D. 1708) had only alluded to the resemblance of electricity to thunder and lightning; Grey (A.D. 1720) had conjectured their identity and implied that they differed only in one degree, while Nollet (A.D. 1746) pointed out a closer relationship than ever before adduced between lightning and the electric spark; but it was left for Franklin to prove the fact with empirical certainty.

Franklin's attention was first directed to electrical studies in 1745, by a letter from Peter Collinson, Fellow of the Royal Society of London, to the Literary Society of Philadelphia, and he first wrote on the subject to that gentleman on the 28th of July, 1747. This was followed by several other similar communications up to April 18, 1754, the whole of which comprise most of what subsequently appeared under the title "New Experiments and Observations on Electricity, made at Philadelphia, in America, by Benjamin Franklin, LL.D. and F.R.S."

Franklin first entertained the idea that lightning was not likely to be attracted by a pointed rod unless the latter was placed at a great height, and he therefore waited for the erection of a tall spire in Philadelphia which he intended to utilize for his observations, but delay in its completion led him to use a kite pointed with an iron rod, not doubting that the electric fluid could, during a thunder-storm, be drawn from it through a string.

The manner of constructing and employing the kite, and the attending results, are thus given in a letter dated Oct. 19, 1752 (Letter XII, "Experiments and observations on Electricity"): "Make a small cross of two light strips of cedar, the arms so long as to reach to the four corners of a large thin silk handkerchief when extended. Tie the corners of the handkerchief to the extremities of the cross, so you have the body of a kite which, being properly

accommodated with a tail, loop and string, will rise in the air like those made of paper; but, this being made of silk, is fitter to bear the wet and wind of a thunder-gust without tearing. To the top of the upright stick of the cross is to be fixed a very sharp-pointed wire, rising a foot or more above the wood. In the end of the twine, next the hand, is to be held a silk ribbon, and where the silk and twine join a key may be fastened. This kite is to be raised when a thunder-gust appears to be coming on, and the person who holds the string must stand within a door or window, or under some cover, so that the silk ribbon may not be wet, and care must be taken that the twine does not touch the frame of the door or window. As soon as any of the thunder clouds come over the kite, the pointed wire will draw the electric fire from them, and the kite with all the twine will be electrified, and the lose filaments of the twine will stand out every way and be attracted by an approaching finger. And when the rain has wetted the kite so that it can conduct the electric fire freely, you will find it stream out plentifully from the key on the approach of your knuckle. At this key, the phial (Leyden jar) may be charged, and from electric fire thus obtained spirits may be kindled, and all the other electric experiments be performed which are usually done by the help of a rubber glass globe or tube, and thereby the sameness of the electric matter with that of lightning completely demonstrated."

It was during the month of June 1752, on the approach of a storm, that he and his son walked out upon the Philadelphia Commons and first raised the kite. At the outset no important results were obtained, but as soon as the cord became wet by the shower that followed, the electric sparks were easily drawn from the key and enabled Franklin to charge and give shocks from a Leyden jar.

Thus, says Sabine, was Benjamin Franklin successful in one of the boldest experiments ever made by man upon the powers of nature, and from that moment he became immortal.

He had already, in 1749, made public the following, which is embodied in one of his letters to Mr. Collinson: "The electrical spark is zigzag, and not straight; so is lightning. Pointed bodies attract electricity; lightning strikes mountains, trees, spires, masts and chimneys. When different paths are offered to the escape of electricity, it chooses the best conductor; so does lightning. Electricity fires combustibles; so does lightning. Electricity fuses metals; so does lightning. Lightning rends bad conductors when it strikes them; so does electricity when rendered sufficiently strong. Lightning reverses the poles of a magnet; electricity has the same effect."

Franklin had, likewise, published at about the same period the plan for an experiment to ascertain from elevated structures whether the clouds that contain lightning are electrified or not. He himself had proposed to put the plan to execution; but he was led to try the kite experiment, and, meanwhile, his suggestions had been successfully acted upon, in France, by M. Dalibard and de Lor, as will be shown later on.

"The lightning, which doth cease to be, ere one can say, 'it lightens.'"—Shakespeare.

"First let me talk with this philosopher; what is the cause of thunder?"—Shakespeare.

". . . a way for the lightning of the thunder."—Job xxviii. 26, and xxxviii. 25.

"It related not to the instances of the *magneticalness* of lightning."—"Hist. of Roy. Soc.," by Thomas Birch, Vol. IV. p. 253.

When specifying the great points of coincidence existing between the ordinary electric discharge and lightning, Franklin, as already partly stated, had remarked that flashes of lightning are frequently waving and crooked, of a zigzag or forked appearance, sometimes diffused and sometimes coloured ("On the Nature of Thunderstorms," W. Snow Harris, London, 1843, p. 24; Priestley, "History and Present State of Electricity," London, 1769, p. 166; "Encycl. Metropol.," article "Electricity"; Biot, "Traité de Physique," Vol. II). In treating of the subject of lightning flashes, Dr. L. D. Gale (trans. of M. F. J. F. Duprez's paper on "Atmospheric Electricity," taken from the memoirs of the Royal Academy of Brussels) alludes to the attempts made by C. G. Helvig to determine the velocity of the linear flashes (Gilbert's *Annalen*, Vol. LI. pp. 136 and 139, ss. 2, 10) which he estimated to be 40,000 to 50,000 feet in a second, and states that M. Weigsenborn, of Weimar (*Comptes Rendus*, Vol. IX. p. 218), calculated the velocity of a flash observed in 1839 to be more than two leagues, while M. François Arago ("Annuaire," etc., pour l'année 1838, pp. 249, 255, 257, 459, estimated the lengths of certain flashes to be 3·3, 3·6, 3·8 leagues. The views of Messrs. Logan (*Phil. Trans.*, 1735, Vol. XXXIX. p. 240), L. J. Gay-Lussac (*Ann. de Chim. et de Phys.*, 1805, Vol. XXIX. p. 105), H. W. Brandes ("Beiträge zur Witterungskunde," etc., 1820, p. 353), C. H. Pfaff and L. E. Kaemtz (J. S. T. Gehler, "Dict. de Phys.," Vol. I. p. 1001, and "Lehrbuch d. Meteor," Vol. II. p. 430), Gabriel Lamé ("Cours. de Phys. de l'Ecole Polytech.," Tome II. 2e partie, p. 82), Becquerel (*Comptes Rendus*, 1839, Tome VIII. p. 216), Faraday (*Philos. Magazine*, 1841, Vol. XIX. p. 104), Pouillet ("Eléments de Phys. et de Météor," Tome II. p. 808), Parrot (J. S. T. Gehler, "Dict. de Phys.," Vol. I. p. 999), are also

set forth in the above-named translation of M. Duprez's valuable work.

Humboldt informs us that "the most important ancient notice of the relations between lightning and conducting metals is that of Ctesias, in his *Indica*, Cap. IV. p. 169. He possessed two iron swords, presents from the King Artaxerxes Mnemon, and from his mother Parysatis, which, when planted in the earth, averted clouds, hail and *strokes of lightning*. He had himself seen the operation, for the king had twice made the experiment before his eyes" ("Cosmos," Vol. II. N. 186). Ctesias was a man of great learning. He was a contemporary of Xenophon, and lived for a number of years at the Court of Artaxerxes Mnemon as private physician to the king. Diodorus states that Ctesias was highly honoured at the Persian court. An abridged edition of the *Indica* was printed by Stephens in 1594 ("Hist. Roy. Soc.," C. R. Weld, London, 1848, Vol. II. p. 93; "La Grande Encyclopédie," Vol. XIII. p. 536; "Biographie Générale," Vol. XII. p. 568).

In imitation of Franklin, Doctor Lining, of Charleston, in South Carolina, sent a kite into a thunder cloud, and by that means dissipated the lightning (*Philosophical Transactions* for 1754, Vol. XLVIII. p. 757).

The opinion entertained by Franklin regarding the nature of electricity differs from that previously submitted by Dufay (A.D. 1733), in the manner shown by Noad at p. 6 of his Manual, London, 1859 edition.

What Dufay considered to be two distinct species of electricities, *vitreous* and *resinous*, Franklin conceived to be two different states of the same electricity, which he called *positive* and *negative*. This, which constitutes the foundation of the present theory of electricity, is usually called the Franklinian theory, but it can be said to belong equally to Dr. Watson, for he had communicated it to the Royal Society before Franklin's opinion on the subject was known in England (*Phil. Trans.* for 1748, Vol. XLV. pp. 49, 491; Thomson, "Hist. Roy. Soc.," p. 436). Noad, in paragraph 12, applies the latter theory to the case of a charged Leyden jar, alluding to Franklin's discovery of the location of electricity in the jar, wherefrom is drawn the conclusion that it is upon the glass that the electricity is deposited, and that the conducting coatings serve "only, like the armature of the loadstone, to unite the forces of the several parts and bring them at once to any point desired" (see "Œuvres de Franklin," trans. of Barbeu-Dubourg, Tome II. p. 16, 3e lettre).

Of his *plus* and *minus* theory, Franklin thus wrote to Mr. Collinson: "To electrise *plus* or *minus* no more needs to be known than this, that the parts of the tube or sphere that are rubbed do, in the

instant of the friction, attract the electrical fire, and therefore take it from the thing rubbing; the same parts, immediately as the friction upon them ceases, are disposed to give the fire they have received to any body that has less."

In an appendix to his official report as U.S. Commissioner at the Paris Universal Exposition of 1867, entitled "Franklin and Electrical Semaphores," Professor Samuel F. B. Morse, LL.D., expressed himself as follows:

"It has frequently been asserted (on what authority I know not) that the first idea of an electric semaphore originated with Franklin. I have sought in vain in the publication of Franklin's experiments and works for anything confirmatory of this assertion. On mentioning the subject to my friend Professor Blake, he kindly proposed examining the writings of Franklin in order to elicit the truth. From him I have received the following:

"'I consulted several works for the purpose of ascertaining, if possible, the foundation for the statement that Franklin suggested the idea of semaphores by static electricity. I have not yet found any such suggestion, but I have noted that, following the experiments by Dr. Watson and others, in England, to determine the *velocity* of the electric discharge, and the time supposed to be required for the electrical discharges across the Thames, by which spirits were kindled, etc. (in 1747), Dr. Franklin (in 1748) made some similar experiments upon the banks of the Schuylkill, and amused his friends by sending a spark "from side to side through the river without any other conductor than the water" (vide Priestley's "History of Electricity"). This was in 1748, at the end of the year. In 1756 "J. A., Esq.," of New York (James Alexander), presented to the Royal Society a proposition "to measure the time taken by an electric spark in moving through any given space" by sending the discharge or spark down the Susquehanna or Potomac, and round by way of the Mississippi and Ohio rivers, so that the "electric fire" would have a circuit of some thousands of miles to go. All this was upon the supposition or assumption that the electric fire would choose a continuous water conductor rather than to return or pass through the earth. Franklin presented a paper in reply, in which he says "the proposed experiment (though well imagined and very ingenious) of sending the spark round through a vast length of space, etc. etc., would not afford the satisfaction desired, though we could be sure that the motion of the electric fluid would be in that tract, and not underground in the wet earth by the shortest way"' ('Franklin's Experiments on Electricity, and Letters and Papers on Philosophical Subjects,' 4to, London, MDCCLXIX, pp. 282, 283).

"Can it be possible that Franklin's experiment of firing spirits and showing the spark and the effects of the electric discharge across the river originated, or forms the foundation for, the statement that he suggested the semaphoric use of electricity?"

After speaking of the experiments, to which allusion was made (at Watson, A.D. 1745), Franklin writes: ". . . It is proposed to put an end to them for this season, somewhat humorously, in a party of pleasure, on the banks of the Schuylkill. Spirits at the same time are to be fired by a spark sent from side to side through the river without any other conductor than the water—an experiment which we some time since performed to the amazement of many. A turkey is to be killed for our dinner by the electrical shock, and roasted by the electrical jack, before a fire kindled by the electrified bottle, when the healths of all the famous electricians in England, Holland, France and Germany are to be drank in electrified bumpers under the discharge of guns from the electrical battery."

It was toward the close of the year 1750 that Franklin entertained the practicability of a lightning conductor (see Winckler, A.D. 1733), and, for this, he says, he was indebted to an experiment made by his friend Mr. Thomas Hopkinson (vide Franklin's "Complete Works," London, 1806, Vol. I. p. 172). In his "Poor Richard's Almanac" for 1753, he refers to the lightning rod as security for "habitations and other buildings from mischief by thunder and lightning."

REFERENCES.—J. B. Le Roy, "Lettera al Rozier," etc., Milano, 1782; "Rec. de Mém. de l'Acad. des Sc." for 1770 and 1773; *Jour. de Phys.*, 1773, Vol. II; Memoirs of M. Beyer, Paris, 1806–1809, and Delaunay's explanation of his theories at pp. 193–198 of his 1809 Manuel.

The many notable observations, experiments and discoveries of Franklin are nowhere more ably reviewed than by his great admirer Dr. Priestley, who devotes much space thereto in his justly celebrated work on electricity.

At p. 92 of his "New Experiments," etc., London, 1774, Franklin alludes to the failure of many European electricians in firing gunpowder by the electric spark, and gives his own method by using a battery of four large glass jars, while at p. 423 of the London edition of his "Letters and Papers," etc., Franklin relates curious observations which are worth mentioning here. He says that he sent a charge of electricity "through a small glass tube that had borne it well when empty, but when filled with water was shattered to pieces and driven all about the room. Finding no part of the water on the table, I suspected it to have been reduced to vapour. I was confirmed in that suspicion afterward when I had filled a like piece

of tube with ink and laid it on a sheet of paper, whereon after the explosion I could find neither any moisture nor any sully from the ink. This experiment of the explosion of water, which I believe was first made by that most ingenious electrician, Father Beccaria, may account for what we sometimes see in a tree struck by lightning, when part of it is reduced to fine splinters like a broom ; the sap vessels being so many tubes containing a watery fluid, which, when reduced to vapour, sends every tube lengthways. And, perhaps it is this rarefaction of the fluids in animal bodies killed by lightning or electricity, that by separating its fibres renders the flesh so tender and apt so much sooner to putrefy. I think, too, that much of the damage done by lightning to stone and brick walls may sometimes be owing to the explosion of water found during showers, running or lodging in the joints or small cavities or cracks that happen to be in the walls."

REFERENCES.—Majus—May—(Heinrich), " Disp. de fulmine " and " Disp. de tonitru," Marp., 1673, as at Pogg., *Annalen*, Vol. II. p. 21 ; Giuseppe Saverio Poli, " La formazione del Tuono," etc., 1772, and his other works on the same subject which appeared during the years 1773, 1779 and 1787 ; *Phil. Trans.* for 1751, Vol. XLVII. pp. 202, 289, 362 ; W. de Fonvielle, " Eclairs et Tonnerres " ; " Terrestrial Magn." for June 1903 ; *Jour. of the Franklin Institute* for 1836, Vol. XVII., p. 183 ; M. le Docteur Sestier, " De La Foudre " ; " Lightning-Rod Conference," Reports of Delegates, by G. J. Symons, 1882 ; Chap. III. s. 3, vol. i. of Van Swinden's " Recueil," etc., 1784 ; *Lumière Electrique*, Tome XL. No. 23, p. 497 ; Giovanni Cardan's work, Lyons, 1663 ; " Library of Literary Criticism," C. W. Moulton, Buffalo, 1901–1902, Vol. IV. pp. 79–106 ; " An Outline of the Sciences of Heat and Electricity," by Thos. Thomson, London, 1830, pp. 347, 423, 432–433 ; " The Electrical Researches of the Hon. Henry Cavendish," Cambridge, 1879, Nos. 350, note, 363 ; " Works of Benj. Franklin," Jared Sparks, London, 1882 ; *Phil. Trans.*, Vols. XLVII. p. 565 ; XLIX. pp. 300, 305, ; L. p. 481 ; LI. p. 525 ; LII. 456 ; also Hutton's abridgments, Vol. X. pp. 189, 212, 301, 629, 632 ; Vol. XI. pp. 189, 435, 609 ; " Bibliothèque Britannique," Genève, 1796, Vol. LI. p. 393 (letter to M. Marc Auguste Pictet) ; Stuber, " Continuation of the Life of Dr. Franklin " ; " An Essay on the Nature of Heat, Light and Electricity " (on the Franklinian hypothesis), by Chas. Carpenter Bompass, London, 1817, Chap. III. s. 3, p. 217 ; " List of Books written by or relating to Franklin," by Paul L. Ford, 1889 ; L. Baldwin, " Mem. of Amer. Acad.," O. S. I. part i. p. 257 ; Sturgeon's " Researches," p. 524 ; J. Bart. Beccari, " De Artif. elect . . ." ; likewise all the references that are given at pp. 26–27 of Ronalds' " Catalogue " ; " Journal des Savants " for June 1817, pp. 348–356.

A.D. 1752.—Dalibard (Thomas François), French botanist and amateur in physics, carries out very carefully the suggestions embodied in Franklin's printed letters and constructs an atmospherical conductor at Marly-la-Ville, about eighteen miles from Paris, where Nollet likewise experimented. Dalibard's apparatus consisted of a pointed iron rod, one inch in diameter and about forty feet long, which was protected from the rain by a sentry box and attached to three long wooden posts insulated by silken strings.

On the 10th of May, 1752, during Dalibard's absence, an old soldier by the name of Coiffier, who was at the time employed as a carpenter and who had been left in charge, on observing the approach of a storm, hurried to the apparatus prepared to carry out the instructions previously given him. It was not long before he succeeded in obtaining large sparks on presenting a phial to the rod, and these sparks, which were all accompanied by a large snapping noise, were likewise obtained by the curate of Marly, M. Raulet, whom he had sent for and with whose aid Coiffier subsequently succeeded in charging an electric jar. On the 13th of May, Dalibard made, to the French Academy of Sciences, a report of the results thus obtained by Coiffier, to whom, it may be said, properly belongs the distinction of having been *the first man who saw the electric spark drawn from the atmosphere.*

On the 18th of the same month of May, M. de Lor, of the French University, drew similar sparks from a rod ninety-nine feet high at his house in the Estrapade, at Paris, and the same phenomenon was afterward exhibited to the French King. It is said that the conductor afforded sparks even when the cloud had moved at least six miles from the place of observation. Other experiments of a like nature were made a few days later by Buffon at Montbar, and, during the ensuing months of July and August, in the vicinity of London, by Canton, who, it is said, succeeded in drawing atmospheric electricity by means of a common fishing rod (Dissertation Fifth, Eighth "Britannica," Vol. I).

An account of the Dalibard and de Lor experiments was transmitted by the Abbé Mazéas, on the 20th of May, to the Royal Society of London.

Mazéas erected, in the upper section of his residence, a magazine consisting of several insulated iron bars connected with the pointed rod. The lightning was brought into the house by means of a projecting wooden pole, having at its extremity a glass tube filled with resin which received a pointed iron rod twelve feet long. This apparatus was, however, too much exposed to afford reliable observations, and Mazéas therefore arranged to make more accurate experiments at the Château de Maintenon, during the months of June, July and October 1753. The results he obtained were communicated to the English Royal Society by Dr. Stephen Hales. The letters of the Abbé Mazéas to the Rev. Stephen Hales, detailing some of M. Le Monnier's experiments as well as observations made by M. Ludolf at Berlin and transmitted by M. Euler, are to be found at pp. 354–552, Vol. XLVII. *Phil. Trans.* for 1753. For Mazéas, see also *Phil. Trans.*, Vol. XLVII. p. 534, Vol. XLVIII. part i. p. 377, and Hutton's abridgments, Vol. X. pp. 289, 434.

Thomas Ronayne in Ireland, and Andrew Crosse[1] in England (see "Account of an apparatus for ascertaining and collecting the electricity of the atmosphere") made use of long wires in horizontal positions insulated by being attached to glass pillars, but Mazéas, in his Maintenon experiments, attached the iron wire by a silken cord to the top of a steeple ninety feet in height, whence it entered an upper room of the castle, a total distance of 370 feet. With this, Mazéas ascertained that electric effects are produced at all hours of the day during clear, dry and particularly hot weather, the presence of a thunderstorm not being requisite for the production of atmospheric electricity. In the driest summer nights he could discover no signs of electricity in the air, but when the sun reappeared the electricity accompanied it, to vanish again in the evening about half an hour after sunset.

References.—W. Sturgeon, "Lectures," London, 1842, pp. 182, 183; *Phil. Trans.*, Vol. XLVIII. part i. pp. 370, 377, etc.; Dalibard's "Franklin," Vol. II. p. 109, etc.; "Mém. de l'Acad. des Sciences," for May, 1762; Nollet, "Letters," Vol. I. p. 9; Franklin's Works, Vol. V. p. 288; English Cyclopædia, "Arts and Sciences," Vol. III. pp. 804–805; "Letters of Thomas Ronayne, to Benjamin Franklin," at p. 137 of Vol. LXII of *Phil. Trans.*, likewise Ronayne both in *Journal de Physique*, Tome VI, and in the *Phil. Trans.* for 1772, Vol. LII. pp. 137–140; also Hutton's abridgments, Vol. XIII. p. 310; Geo. Adams, "Essay on Elect.," London, 1785, p. 259.

A.D. 1752.—Freke (John), surgeon to St. Bartholomew's Hospital, London, gives, in the Second Part of "A Treatise . . . of Fire," the third edition of his "Essay to Show the Cause of Electricity," etc., originally published in 1746, while in the Third Part of the same work he shows the "Mechanical Cause of Magnetism, and why the compass varies in the manner it does."

He says (pp. 90–91): "It had been impossible that this wonderful *Phenomenon* of Electricity should ever have been discovered, if there had not been such things as are non-electricable; for, as fast as this Fire had been driven on anything its next neighbour would have carried it farther; but, when it was most wonderfully found, that anything which was suspended on a silk cord (that being non-electricable) was obliged to retain the Fire, which by Electrical Force was driven on it; and when, moreover, it appeared, that any person or thing, being placed on a cake of bees-wax (which is also a non-electricable) could no more part with its Fire than when suspended in [*sic*] a silk cord; I think it will become worthy of inquiry, why they are not electricable." And, at p. 136, he adds:

[1] Mr. Andrew Crosse (1784–1855) was a distinguished English scientist, author of "Experiments in Voltaic Electricity," 1815, alluded to in *Phil. Magazine*, Vol. XLVI. p. 421 and in Gilb. "Ann.," Bd. XLI. s. 60. See "Dict. of Nat. Biog.," Vol. XIII. p. 223, and the many references thereto annexed.

"I think it a great pity that the word *Electricity* should ever have been given to so wonderful a *Phenomenon*, which might properly be considered as the first principle in nature. Perhaps the word *Vivacity* might not have been an improper one; but it is too late to think of changing a name it has so long obtain'd." In the Third Part, he explains that "by the Fire passing from and to the Sun, it so pervades iron aptly placed, as to make it attractive and produce the various operations of magnetism."

REFERENCE.—"Gentleman's Magazine," London, Vol. XVI for 1746, pp. 521, 557.

A.D. 1752.—In this year was published at Leipzig the "Biblia Naturæ," written by John Swammerdam, a celebrated Dutch natural philosopher (1637–1682), all of whose works were translated into English and published in folio during the year 1758.

In the second volume of the *Biblia*, he thus alludes to one of many experiments made by him in 1678, before the Grand Duke of Tuscany: "Let there be a cylindrical glass tube in the interior of which is placed a muscle, whence proceeds a nerve that has been enveloped in its course with a small silver wire, so as to give us the power of raising it without pressing it too much or wounding it. This wire is made to pass through a ring bored in the extremity of a small copper support and soldered to a sort of piston or partition; but the little silver wire is so arranged that on passing between the glass and the piston the nerve may be drawn by the hand and so touch the copper. The muscle is immediately seen to contract."

Through Swammerdam, the Germans lay claim to the origin of what has been called galvanism. It certainly cannot be denied that the above-described experiment closely resembles that which made Galvani famous (A.D. 1786).

REFERENCES.—Swammerdam's Biography, also Dissertation Fifth, in the eighth edition "Encycl. Brit."; the note at p. 491 of Ronalds' "Catalogue"; "Gen. Biog. Dict.," London, 1816, Vol. XXIX. pp. 45–47; Eloy, "Dict. Hist. de la Méd.," Vol. IV; "Biog. Générale," Vol. XLIV. pp. 706–708; Cuvier, "Hist. des Sc. Naturelles," Vol. II. pp. 427–433; Schelhorn, "Amænitates liter.," Vol. XIV; "Biblioth. Hulthemiana," Gand, 1836, Vol. II; Boerhaave, Preface to "Biblia Naturæ."

A.D. 1752.—On the 16th of April, 1752, is read before the Royal Society a letter written by John Smeaton, a very prominent English engineer and inventor (1724–1792), to Mr. John Ellicot, giving an account of the electrical experiments *in vacuo* made with his improved air pump at the request of Mr. Wilson. This account, fully illustrated, appears in the Society's Vol. LXVII for the years 1751 and 1752, pp. 415–428.

He observes that, upon heating the middle of a large iron bar

to a great heat, the hot part can be as strongly electrified as the cold parts on each side of it. He also finds that if anybody who is insulated presses the flat part of his hand heavily against the globe, while another person standing upon the floor does the same, in order to excite it, the one who is insulated will hardly be electrified at all; but that, if he only lays his fingers lightly upon the globe, he will be very strongly electrified.

References.—Wilson, "Treatise on Electricity," pp. 129–216; *Phil. Trans.* XLVI. p. 513; "Dict. of Nat. Biography," Vol. LII. pp. 393–395; "Biog. Univ." (Michaud), Vol. XXXIX. p. 445; Smile's "Lives of the Engineers—Smeaton and Rennie"; Flint's "Mudge Memoirs," Truro, 1883.

A.D. 1752–1753.—M. de Romas, Assessor to the Presideal of Nerac, in France, repeats the experiment of Benjamin Franklin, and succeeds finally in bringing from the clouds more electricity than had before been taken by any apparatus.

He constructed a kite seven feet five inches high and three feet wide, with a surface of eighteen square feet, and, having wound fine copper wire around a strong cord through its entire length of about eight hundred feet, he raised the kite to a height of five hundred and fifty feet on the 7th of June, 1753. Sparks two inches in length were at first drawn by a discharging rod, and, when the kite was afterwards allowed to reach an elevation of six hundred and fifty feet, he received many flashes one foot long, three inches wide and three lines diameter, accompanied by a noise audible at as great a distance as five hundred feet.

On the 16th of August, M. de Romas raised the kite with about one thousand feet of string and obtained thirty beams of fire, nine or ten feet long and about an inch thick, accompanied by a noise similar to that of a pistol shot ("Encycl. Britannica," eighth edition, Vol. VIII. p. 582). Three years later, August 26, 1756, and also during the year 1757, De Romas obtained similar results from numerous experiments. He finally apprehended much danger from the raising of the kite and thereafter coiled the string upon a small carriage, which he drew along by means of silken lines as the cord was being unwound.

The researches of De Romas concerning the electricity of isolated metallic bars are embraced in six letters addressed by him to the Bordeaux Academy of Sciences between July 12, 1752, and June 14, 1753. It is reported that they have never been printed and that they are kept, together with other manuscript matter of the same physicist, in the private archives of the institution.

The experiments of De Romas upon isolated bars were first repeated by Boze at Wittenberg, by Gordon at Erfurt, and by

Lomonozow in Russia (*Phil. Trans.*, Vol. XLVIII. part ii. p. 272). M. Veratti, of Bologna, obtained the electric spark in all weathers, through a bar of iron resting in sulphur, and Th. Marin, of the same city, by means of a long iron pole erected upon his dwelling, studied the relationship of rain and atmospheric electricity (Musschenbroek, "Cours de Physique," Vol. I. p. 397).

References.—*Journal des Sçavans* for October, 1753, p. 222; "Mémoire sur les moyens," etc., par De Romas, Bordeaux, 1776; Sturgeon's "Annals," etc., Vol. V. p. 9; Harris, "Electricity," p. 176; Priestley, "History," etc., 1775, pp. 326–329; "Mémoires de Mathématique," etc., Vol. II. p. 393, and Vol. IV. p. 514; "Etude sur les travaux de De Romas," p. 491, by Prof. Mergey, of Bordeaux, which latter work won a prize for its author in 1853; Becquerel, "Traité expérimental," etc., 1834, Vol. I. pp. 42–43; likewise the results obtained by Prof. Charles in "Traité de Physique Expérimentale," etc., par Biot, Paris, 1816, Vol. II. pp. 444, 446, and in Peltier's Introduction to his "Observations et Recherches Expérimentales," etc., Paris, 1840, p. 7, as well as Brisson's "Dict. de Phys.," Paris, 1801, Vol. II. p. 174, and "Mémoires des Savants Etrangers," 1755, Vol. II. p. 406.

A.D. 1753.—M. Deslandes, member of the French Royal Academy of Sciences, is the author of "Recueil de Différents traités de Physique," the third volume of which contains his memoir on the effects of thunder upon the mariner's compass. He alludes to the observations made thereon by Dr. Lister of London (well known by his "Historiæ Animalium Angliæ," Lugd., 1678), as well as to many experiments made by Musschenbroek and by others noted in the *Philosophical Transactions.*

A.D. 1753.—Prof. George William Richmann (1711–1753), native of Sweden and member of the Imperial Academy of St. Petersburg, who had already constructed an apparatus for obtaining atmospherical electricity according to Franklin's plans, was attending a meeting of the Russian Academy of Science, on the 6th of August, 1753, when his ear caught the sound of a very heavy thunder clap. He hastened away in company with his engraver, M. Sokolow, and upon their arrival home they found the plummet of the electrometer elevated four degrees from the perpendicular. Richmann stooped toward the latter to ascertain the force of the electricity, and "as he stood in that posture, a great white and bluish fire appeared between the rod of the electrometer and his head. At the same time a sort of steam or vapour arose, which entirely benumbed the engraver and made him sink on the ground." Sokolow recovered, but Richmann had met with instant death.

References.—"Library of Useful Knowledge," London, 1829; "Electricity," p. 59, also p. 33; "Lettre sur la mort de Richmann," par C. A. Rabiqueau, Paris, n. d.; "Comment. Acad. Petrop.," XIV. pp. 23, 301–302, also the "Novi Comment.," IV. pp. 25, 235 and 299;

"Biog. Générale," Vol. XLII. p. 258; "Gentleman's Magazine," London, Vol. XXIII., 1753, p. 431 and Vol. XXV. for 1755, p. 3; Singer, "Electricity," p. 217; Harris, "Electricity," p. 177; *Phil. Trans.*, Vol. XLVIII. part ii. pp. 763–765, 772; also Vol. XLIX. part i. pp. 61, 67, and the abridgments by Hutton, Vol. X. pp. 525, 574–577; "La physique à la portée de tout le monde," par le Père Paulian, Vol. II. p. 357; "Hist. de l' Acad. des Sciences," pour 1753, p. 78; "Franklin in France," 1888, Part. I. p. 5.

A.D. 1753.—Canton (John), an English savant (1718–1772), announces his most important discovery that vitreous or resinous electricity may be produced at will in the same tube. This he proves on taking a tube, which had been roughened by grinding it with thin sheet-lead and flour-of-emery mixed with water, and which developed vitreous electricity when rubbed with dry oil silk, and resinous or negative electricity when rubbed with new flannel. Rough quartz will, it is said, show like results. He also took a tube, of which only one-half had been made rough while the other half was polished, and he demonstrated that the different electricities are produced at a single stroke with the same rubber.

He likewise discovered that the exciting power of the rubber or cushion of the electrical machine will be very greatly increased by applying to it an amalgam of mercury and tin mixed with a little chalk or whiting (see Winckler, at A.D. 1733, for the introduction of the cushion).

His very remarkable experiments upon many descriptions of tourmaline, reported to the Royal Society in December 1759, were followed by many others detailed by Priestley, at pp. 298–301 of his "History of Electricity," London, 1775, and Canton was the first to discover the electrical properties of the topaz, which latter were made known during the early part of the year 1760. (Consult Wilhelm Hankel, "Uber die therm. eigen. des Topases," Leipzig, 1870.)

He was also the first to establish properly the fundamental fact of electrification by induction, or, as he terms it, "relating to bodies immerged in electric atmospheres," which afterward led Wilcke (A.D. 1757) and Æpinus (A.D. 1759) to the method of charging a plate of air like a plate of glass, and to make the most perfect imitation of the phenomena of thunder and lightning (George Adams, "Essay on Electricity," London, 1799, pp. 351–356; Noad, "Manual," Chapter I, and Priestley, "History," etc., s. 5). The paper containing an account of Canton's experiments was read before the Royal Society, December 6, 1753. The principle enounced is that "the electric fluid, when there is a redundancy of it in any body, repels the electric fluid in any other body when they are brought within the sphere of each other's influence and drives it

into the remote parts of the body; or quite out of it, if there be any outlet for that purpose. In other words, bodies immerged in electric atmospheres always become possessed of the electricity contrary to that of the body in whose atmosphere they are immerged."

Canton is the first to show that the air of a room can be electrified either positively or negatively, and can be made to retain the electricity when received. He thus explains his method: "Take a charged phial in one hand and a lighted candle insulated in the other, and, going into any room, bring the wire of the phial very near to the flame of the candle and hold it there about half a minute, then carry the phial and candle out of the room and return with the pith balls (suspended by fine linen threads) held out at arm's length. The balls will begin to separate on entering the room and will stand an inch and a half or two inches apart when brought near the middle of it."

The construction of artificial magnets by Canton, through the combination of the Duhamel (A.D. 1749) and the Michell (A.D. 1750) methods, as well as without the aid of natural loadstones or artificial magnets, is detailed by Noad at Chapter XV of his "Manual," London, 1859.

REFERENCES.—*Phil. Trans.*, Vol. XXXV. p. 137 (Berlinghieri, V. L.); Vol. XXXVII. p. 294 (Marcel, A.); Vol. XLVII. p. 31; Vol. XLVIII. part i. pp. 350, 356, and Part II. pp. 780, 782 and 784, also Vol. XLIX. part i. p. 300; Vol. LI. pp. 398, 403, and Vol. LII. part ii. pp. 457, 461; and the abridgments of Hutton, Vol. X. pp. 131, 421, 532; Vol. XI. pp. 421, 609; A.D. 1722, and A.D. 1752; "A Course of Lectures on Nat. Philos. and the Mechanical Arts," by Thos. Young, London, 1807, Vol. I. p. 372; II. pp. 64, 243; "The Electrical Researches of Hon. Hy. Cavendish," 1879, Nos. 117, 205; Descriptions and Drawings of the various electric friction machines can be seen in Priestley's "History," Plates IV–VIII, and in Albrecht's "Geschichte d. Electricität," 1885, pp. 20–30; *Acta Acad. Petr.*, I., 1778; "Gentleman's Magazine" for Sept. 1759. See likewise the *Phil. Trans.* for Monday, January 21, 1666, p. 375, and George Adams' "Essay on Electricity," etc., London, 1799, p. 579, for method of making the artificial Bolonian stone or Canton's phosphorus.

A.D. 1753.—Beccaria (Giovanni Baptista) (1716–1781), a very ingenious and industrious Italian electrician and astronomer, is the author of several quite important works on electricity.

Father Beccaria, as he is sometimes called from having been a member of the religious order of the Pious Schools, proved at the time to be the most indefatigable follower of Franklin in the study of atmospheric electricity. He was the first who recorded the phenomena of thunderstorms, and his many observations thereon are detailed throughout Part I. period x. and s. 10 of Priestley's great work on electricity. Beccaria says that all clouds, whether of thunder, rain, snow or hail, are formed by the electric fluid; that the electric matter is continually darting from the clouds in

one place at the same time that it is discharged from the earth in another; and that the clouds serve as conductors to convey the electric fluid from those places of the earth which are overloaded with it to those which are exhausted of it. Having shown that the polarity of the magnetic needle is determined by the direction in which the electric current has passed through it, he suggests taking the polarity acquired by ferruginous bodies as a test for ascertaining the kind of electricity with which the thunder cloud is charged.

He also shows that the meteor called a *falling star* is an electrical appearance, explains the cause of the peculiar noise attending the electric spark, and states that the passage of electricity is not instantaneous through the best conductors. He found a spark to occupy at least half a second in passing through 500 feet of wire, and six and a half seconds through a hempen cord of the same length, although when the cord was dampened it passed through it in two or three seconds.

He was the first to show the electric spark while in its passage through water, and he observed that the water sank in the tubes whenever a spark passed from one to the other as the air was repelled by the electric fluid. He found the effect of the electric spark upon water greater than the effect of common fire on gunpowder, and says he does not doubt that, if a method could be found of managing them equally well, a cannon charged with water would be more effective ("dreadful") than one charged with gunpowder.

He demonstrates that air, contiguous to an electrified body, gradually acquires the same electricity; that the electricity of the body is diminished by that of the air; that there is mutual repulsion between air and the electric fluid, and that the latter, in passing through any portion of air, creates a temporary vacuum.

The production of what he calls his *new inventive phosphorus* and the method he employs for *revivifying metals*, are described, respectively, at pp. 365 and 282 of his "Lettere dell' elettricismo."

REFERENCES.—Beccaria, "Lettere," etc., Bologna, 1758, pp. 146, etc., 193, 266, 268, 290, 310, 345; likewise his "Elettricismo Artificiale," Turin, 1753, pp. 110, 114, 227; *Phil. Trans.* for 1760, Vol. LI. p. 514; 1762, p. 486; 1766, Vol. LVI. p. 105; 1767, Vol. LVII. p. 297; 1770, Vol. LX. p. 277; 1771, p. 212, also Hutton's abridgments, Vol. XI. p. 435; Vol. XII, pp. 291, 445; Vol. XIII. p. 50; Wartmann, "Mém. sur les Etoiles filantes"; Humboldt, "Relation historique," Tome I; Lardner, "Lectures," Vol. I. pp. 429–444; Sturgeon's *Annals*, Vol. VI. pp. 415–420, 425–431, and Vol. VIII. p. 180; Noad, "Manual," London, 1859, p. 197; Louis Cotte, "Observation . . ." Paris, 1769 and 1772; "Mém. de Paris" for the same years and *Jour. de Phys.* for 1783; Ant. Maria Vassalli-Eandi, "Notizia sopra la vita . . . di Beccaria," 1816; Carlo Barletti, "Nuove Sperienze . . ." Milano, 1771; "Biog. Générale," Vol. V. pp. 77–78; "The Electrical Researches of Hon. Henry Cavendish," Cambridge, 1879, No. 136; Hale, "Franklin in France," Boston, 1888,

Part I. p. 447; Humboldt, "Cosmos," London, 1859, Vol. I. pp. 113–136, 202, 337; Vol. V. pp. 217–219, for the observations of Beccaria, Rozier, Kepler, Benzenberg, Brandes, Bogulawski, Nicholson, Arago and others on atmospheric electricity, aerolites, etc. See likewise Beccaria's letters to Jean Claude Fromond, the Italian physicist (1703–1795), relating his experiments tending to prove that electric motions do not occur *in vacuo*, also his letters to the Princess Giuseppina di Carignano on the electricity of the moon, as well as to Jean Baptiste Le Roy and to Jacopo Bartolommeo Beccari relative to experiments with his kite; "Scelta di Opuscoli," of Amoretti, Campi, Fromond and Soave, Vols. XIX. XXI. XXXII.; "Opuscoli Scelti," II. 378; III. 243, 284, 377; V. 19.

A.D. 1753.—Bazin (Gilles Augustin), French physician and naturalist, publishes, at Strasbourg, an illustrated treatise on Magnetic Currents ("Description des Courants Magnétiques," etc.), which also contains his observations upon the magnet, and a supplement to which appears during the year 1754.

References.—"La Grande Encyclopédie," Vol. V. p. 974; Michaud, "Biog. Univ.," Vol. III. p. 353; Ninth "Britannica," Vol. XV. p. 242.

A.D. 1753.—C. M., *i. e.* Charles Morrison and not Charles Marshall, of Greenock, Scotland, writes, from Renfrew, February 1, 1753, to the *Scots' Magazine*, a letter entitled "An Expeditious Method of Conveying Intelligence," wherein is first suggested a practical manner of transmitting messages by frictional electricity.

A full copy of this letter appears at pp. 7–9 of Robert Sabine's "Electric Telegraph," London, 1872, and at p. 9, 103, No. 570, of the *Scientific American Supplement* for December 4, 1886, the last-named also reproducing some correspondence establishing the identity of Charles Morrison which was found in the papers of Sir David Brewster.

In the article of Auguste Guérout, which appeared in *La Lumière Electrique* early in 1883, C. M. is alluded to as Charles Marshall. This is likewise the case in Johnson's Encyclopædia, 1878, Vol. IV. p. 757. Fahie gives ("History of the Electric Telegraph," London, 1884, pp. 68–77) a full account of the many inquiries instituted to establish the identity of C. M., which he admits to stand for Charles Morrison, although, at p. 81 of the same work, is given a letter of Sir Francis Ronalds alluding to Charles Marshall, of Renfrew. An article in *Cornhill Magazine*, Vol. II for 1860, pp. 65–66, speaks of an elderly Scotch lady who remembered a very clever man named Charles Marshall, who could make "lichtnin' write an' speak" and who could "licht a room wi' coal-reek" (coal-smoke).

In his remarks upon the afore-named letter, made during the year 1859, Sir David Brewster says: "Here we have an electric telegraph upward of a hundred years old, which at the present day would convey intelligence expeditiously, and we are constrained to

admit that C. M. was the inventor of the electric telegraph. . . . Everything done since is only improvement."

REFERENCES.—*Scots' Magaz.*, XV. p. 73; "Le Cosmos," Paris, Feb. 17, 1854; "Dict. of Nat. Biog.," Vol. XXXIX. p. 107; *Athenæum* of Nov. 5, 1864; Lesage, at A.D. 1774; Th. Du Moncel, "Exposé des applications de l'électricité," Paris, 1874, Vol. III. pp. 1 and 2.

A.D. 1754.—Diwish (Prokop), Diviss—Divisch (Procopius), a monk of Seuftenberg, Bohemia (1696–1765), erects, June 15, 1754, a lightning protector upon the palace of the curator of Prenditz, Moravia. The apparatus was composed of a pole surmounted by an iron rod supporting twelve curved up branches and terminating in the same number of metallic boxes filled with iron ore and closed by a boxwood cover traversed by twenty-seven sharp iron points which plunged at their base in the ore. All the system of wires was united to the earth by a large chain. The enemies of Diwish, jealous of his success at the court of Vienna, excited the peasants of the locality against him, and, under the pretext that his lightning rod was the cause of the great drought, they made him take down the lightning rod which he had utilized for six years and then imprisoned him. What is most curious is the form of this first lightning rod, which is of multiple points, like the one M. Melseu afterward invented.

REFERENCES.—*Poggendorff*, Vol. I. p. 580, for Procopius Divisch's "Erfand einen Wetter Ableiter"; *Scientific American*, Sept. 10, 1887, p. 160; "Kronika Prace," by Pokorny, of Prague; "Historical Magazine," Feb. 1868, Art. XII. p. 93; "Prague News," for 1754, art. of Dr. Scrinci.

A.D. 1754.—Ammersin (Rev. Father Windelinus), of Lucerne, Switzerland, announces in his "Brevis relatio de electricitate," etc., that wood properly dried till it becomes very brown is a non-conductor of electricity. We have already mentioned the observation made by Benjamin Wilson (A.D. 1746) that, when a dry, warm piece of wood is broken across, one of the pieces becomes vitreously and the other resinously electrified.

Ammersin advises boiling the dried wood in linseed oil or covering it with varnish to prevent the possible return of moisture, and he states that wood thus treated seems to afford stronger appearances of electricity than does even glass (*Phil. Trans.*, Vol. LII. part i. p. 342).

REFERENCES.—Ammersin, "Kurze Nachricht," etc., pub. at Basel, 1771, and translated the same year by Jallabert, who embodied it in his "Versuche über die Elektricität," etc.

A.D. 1754.—In his "Dissertations sur l'incompatibilité de l'attraction," etc., Le Père Gerdil, Professor of Philosophy in the Royal University of Turin, speaks of agencies of which we shall

never know anything and of others with which we shall inductively become acquainted, although we shall always ignore many of their respective quantities, qualities and differences. He says that the electric fluid explains the sympathy known to exist between amber and straws—shown by the analogy observed between electricity and magnetism to be the same as that existing between iron and the loadstone.

A.D. 1754.—Mr. Strype produces the sixth and last edition of the original "Survey of London," by John Stow, which first appeared during the year 1598.

In his account of Cornehill Ward, allusion is made to the "fair new steeple" of the Church of Saint Michael th' Archangel, "begun to be built in the year 1421," and, at p. 74, occurs the following: "As I have oft heard my father report, upon St. James' night, certain men in the loft next under the bells, ringing of a peal, a tempest of lightning and thunder did arise, an ugly shapen sight appeared to them, coming in at the South window and lighted on the North, for fear whereof they all fell down and lay as dead for the time, letting the bells ring and cease of their own accord; when the ringers came to themselves, they found certain stones of the North window to be razed and scratched, as if they had been so much butter, printed with a lion's claw; the same stones were fastened there again and so remain to this day."

In one of the notes to William T. Thoms' reprint of the above-named "now perfectly invalyable" work, he says: "It is quite clear from the tone in which Stow speaks of this 'ugly shapen sight' and the marks 'printed with a lion's claw,' that he suspected this instance of the power of the electric fluid to be nothing less than a visitation from the foul fiend himself."

Speaking of St. Paul's Cathedral, Stow tells us that its pulpit cross "was by tempest of lightning and thunder defaced," and that "on Wednesday, the fourth of June (in the year 1561), betweene three, four and five of the clock, in the after-noone, the steeple of Paule's in London, being fired by lightning brast forth (as it seemed to the beholders) two or three yards beneath the foote of the crosse, and from thence burnt downe the speere to the stone worke and bels, so terribly, that within the space of foure houres, the same steeple with the roofes of the church . . . were consumed." Very curious and interesting reading will be found in the "Burnynge of Paule Church, London, in 1561, and the iiii day of June, by lyghtnynge at three of the clocke . . ." by Wyllyam Seres, London, 1563; as well as in his previous work on like subject, published in 1561. See Report in "Archæologia," London, 1794, Vol. XI. pp. 72–86;

likewise the entry at A.D. 1769, relative to another lightning stroke in 1772.

Stow is perhaps best known by his "Annales, or a Generalle Chronicle of England." In that portion of the latter work devoted to "the life and raigne of Queene Elizabeth" he states (London ed., 1631, p. 809) "that the knowledge and use of the sea compasse or needle was neither familiar nor understood but few yeeres before" the time of the navigators John Hawkins, Francis Drake, Martin Frobisher and Thomas Candish, and he adds (at p. 810) "that the honour of that invention, as touching the propertie of the Magneticall needle in pointing towards the Poles is attributed by (Flavius) Blondus in his *Italia Illustrata* (in the description of Campadia Felix) and by the great writer Paulus Jovius in lib. xxv. of his History in the end [*sic*], to the citizens of Amalfi. . . . The author's name is no more particularly recorded, then [*sic*] to be one Flavio . . . for to him that honour is given by Francis Lopez, of Gomara, in his West Indian History, lib. i. cap. 9, and by Peter Ciezius, in lib. ii. cap. 9, of his Indian Story, and by Pandulph : Collenutius in his History of Naples, who, three hundred yeeres since, namely in the yeere of our Saviour 1305, discovered that propertie in the Magnes and applied it to navigation" (see, for Flavius Blondus : George Hakewill, "An apologie," etc., Oxford, 1635, lib. iii. s. 4, and lib. v. p. 60; "Blondi Flavii Fortiriensis . . . Italia Illustrata," 1531, folio; Flavius Blondus (Flavio Biondo), "Roma Ristaurata et Italia Illustrata," Vinezïa, 1558, 12mo; Niceron, "Mémoires . . . des hommes illustres," Paris, 1731, Vol. XVI. pp. 274-281).

A contemporary of Flavius Blondus, by name Michael Angelus Blondus (1497–1560), author of "De Ventis et Navigatione," published at Venice in 1546, likewise alludes to the polarity of the needle, and gives a curious illustration of a mariner's compass at Chap. XXIV. p. 15, of the last-named work. (For M. A. Blondus, see "La Grande Encyclopédie," Vol. VI. p. 899.)

Stow makes reference (p. 810) to Dr. Gilbert's *De Magnete*, to the "diuision of the plot or playne of the compasse into the thirty-two points," considered by "Goropius in his lib. iii. *De Origin. Hispanicis*, to have been the inuention of some Germane," and to the manner and "meanes saylers vsed to sayle, before they atteined the knowledge of the compasse."

A.D. 1755.—Eeles—Eales (Henry), a prominent scientist of Lismore, Ireland, communicates to the Royal Society, on the 25th of April, 1755, a paper concerning the electrical property of steam and exhalations of all kinds. Eeles' theory of the electricity of vapour ("On Vesicles and Atmospheres of Electricity"), afterward devel-

oped by Sir John Herschel, is fully explained in the " Encycl. Brit." article on " Meteorology " (par. 135, etc.), and is also alluded to at p. 43 of Harris' " Electricity," as well as at p. 153, Vol. XLIX. part i. of the *Philosophical Transactions.*

Mr. Eeles showed, that while the Leyden jar is being charged, both the inside and the outside have the same kind of electricity and that the negative electricity does not appear until the machine has ceased turning. Eeles' hypothesis, extracted from his " Philosophical Essays," and from the analysis of a course of lectures delivered at Trinity College, Cambridge, by Mr. Atwood, is treated of at length by George Adams in the fourth chapter of his " Essay on Electricity," wherein pertinent allusion is also made to the fact of Mr. Eeles having been purposely shut out of Priestley's " History and Present State of Electricity."

REFERENCES.—*Philosophical Transactions,* Vol. XLVII. p. 524; *Phil. Mag. and Journal,* Vol. XLIV. p. 401 (1814).

A.D. 1756.—Le Chevalier Jacques C. F. de la Perriere de Roiffé (not Reiffé) is the author of " Méchanismes de l'Electricité et de l'Univers," published at Paris, wherein he pretends to account for all electrical phenomena.

At p. 12 of his Préface, he curiously states that as everybody comprehends the distinction between elastic and non-elastic bodies, likewise the existence, nature and diversity of the properties of atmospheric fluids, with which all bodies are impregnated and by which they are surrounded, also the various expansive modes of activity to which they are subject, as well as their immiscibility as regards the surrounding air, without which latter they could not, however, subsist, he will in his new theory apply these principles to the mechanisms of electricity and of the universe as affected by the general laws and the invariable results attaching to shock and motion.

A.D. 1756.—In the " Subtil Medium Proved," etc., of Mr. R. Lovett, lay-clerk of the cathedral church at Worcester, England, are shown numerous medical cures successfully made by electricity. He asserts that the electric fluid is almost a specific in all cases of violent pains, like obstinate headache, the toothache, sciatica, etc., but that it has not succeeded so well in rheumatic affections. He states that electricity properly administered has never caused injury, and he alludes to equally successful cures made by the Rev. John Wesley and by Dr. Wetzel, of Upsal.

The well-known physician, Antonius de Haen, during several years' experience, made many cures of paralysis, St. Vitus' dance,

etc., by the agency of electricity, as related in his *Ratio Medendi*, Vol. I. pp. 199, 200, 233, 234 and 389. Allusion has been made in these pages to the employment of electricity for medical purposes by Kratzenstein (A.D. 1745) and by Jallabert (A.D. 1749), and Priestley named many others who have likewise used it successfully in their practice.

REFERENCES.—" Subtil Medium Proved," etc., pp. 76, 101 and 112; also his " Philosophical Essays," Worcester, 1761 and 1766, and his " Electrical Philosopher," 1774; Wesley's " Desideratum, or Electricity made Plain and Useful," p. 3; Joseph Veratti, " Observations . . . pour guérir les paralytiques. . . ." La Haye, 1750.

A.D. 1757.—Dr. Darwin, of Lichfield, addresses to the Royal Society of London a paper which is read May 5, 1757, and in which he gives an account of experiments to prove that the electric atmosphere does not displace air, and that all light, dry, animal and vegetable substances, in particular, are slow to part with the electricity with which they have been charged (*Phil. Trans.*, Vol. L. part i. pp. 252 and 351).

A.D. 1757.—Euler (Leonard), a native of Switzerland, who studied under the Bernoullis, and who succeeded Daniel Bernoulli as Professor of Mathematics at St. Petersburg, was undoubtedly one of the greatest analysts the world has ever produced (" Encycl. Brit.," Fifth Dissertation of the eighth edition, Vol. I. p. 742).

He adopted the theory of Descartes that the magnetic fluid moves from the equator to the poles, and he endeavoured to determine mathematically the course of the magnetic needle over the earth's surface. He announces that " the magnetic direction on the earth follows always the small circle which passes through the given place and the two magnetic poles of the earth," or, as worded by Sir David Brewster, that " the horizontal needle is a tangent to the circle passing through the place of observation and through the two points on the earth's surface where the dipping needle becomes vertical or the horizontal needle loses its directive power."

He entertained very peculiar ideas regarding the source of power in the loadstone, the pores of which he imagined were filled with valves admitting of the entrance of the current and preventing its return. His notions on this subject are best given in his own words: " Non-magnetic bodies are freely pervaded by the magnetic matter in all directions; loadstones were pervaded by it in one direction only . . . water, we know, contains in its pores particles of air . . . air, again, it is equally certain, contains in its pores a fluid incomparably more subtile, viz. *æther*, and which, on many occasions, is separated from it, as in Electricity; and now we see a still further

progression, and that ether contains a matter much more subtile than itself—the magnetic matter which may, perhaps, contain in its turn others still more subtile. . . . The loadstone, besides a great many pores filled with ether, like all other bodies, contains some still much more narrow into which the *magnetic matter* alone can find admission. These pores are disposed in such a manner as to have communication with each other, and constitute tubes or canals through which the magnetic matter passes from the one extremity to the other. Finally, this matter can be transmitted through these tubes only in one direction, without the possibility of returning in the opposite direction. . . . As we see nothing that impels the iron toward the loadstone, we say that the latter attracts it. It cannot be doubted, however, that there is a very subtile, though invisible matter, which produces this effect by actually impelling the iron towards the loadstone."

References.—"Journal des Savants" for March and April 1868; Euler's "Letters," translated into English, 1802, Vol. I. p. 214, and Vol. II. pp. 240, 242, 244; "Berlin Memoirs," for 1746, p. 117; 1757, p. 175; 1766, p. 213; *Poggendorff*, Vol. I. p. 702; "Nova Act. Petropol." for 1779, Vol. III; "Pièces de Prix de l'Acad. des Sc. de Paris," Vol. V. Mém. II and IX, this last-named publication containing likewise a joint Memoir of D. Euler, J. Bernoulli and E. F. Dutour upon the mariner's compass, which appeared in Paris during 1748; Whewell, "History of the Inductive Sciences," 1859, Vol. I. pp. 225, 367, 370; Vol. II. pp. 32, 40.

His son, Albert Euler, censured Halley's magnetical hypothesis, and proposed, in 1766, a theory requiring the assumption of only two poles, distinct, however, from those of the terrestrial axis.

A.D. 1757.—Dollond (John), who was at first a silk weaver at Spitalfields, England, which occupation he abandoned in order to give his exclusive attention to scientific experimental studies, discovered the laws of the dispersion of light and constructed the first achromatic telescope as well as several improved instruments for magnetic observations. A full description of the most important of these, accompanied by illustrations, can be found in the articles of the "Encyclopædia Britannica" on magnetic instruments.

References.—Kelly's "Life of John Dollond," London, 1808; *Phil. Mag.*, Vol. XVIII. p. 47; Thomas Thomson, "Hist. of Roy. Soc.," London, 1812, pp. 379–382; "Directions for using the Electric Machine made by P. and J. Dollond," London, 1761.

A.D. 1757. — Wilcke (Johann Karl), a very distinguished scientist of Stockholm (1732–1796), introduces new phenomena respecting the production of electricity produced by melting electrical substances, which he discovers in continuation of experiments begun by Stephen Grey. He gives the name of *spontaneous* to the electricity

produced by the liquefaction of electrics, observing that the electricity of melted sulphur does not appear until it commences to cool and to contract, its *maximum* being reached at its point of greatest contraction. Melted sealing wax, he says, becomes negatively electrified when poured into glass, but, when poured into sulphur, it is positively electrified, leaving the sulphur negative (Sir Humphry Davy, "Bakerian Lectures," London, 1840, p. 36 and notes).

While in Berlin, he and Æpinus investigate the subject of electric atmospheres, and they are led to the discovery that plates of air can be charged in the same manner as plates of glass. (See Canton, A.D. 1753.) This they did by suspending large wooden boards, which were covered with tin and whose flat surfaces were held parallel to and near each other. They found that upon electrifying one of the boards positively the other was always negative, and that with them could be given shocks like those produced by a Leyden jar. They likened the state of the boards to the condition of the clouds and the earth during a thunderstorm, the earth being in one state and the clouds in the opposite, the body of air between them answering the same purpose as the small plate of air between the boards or the plate of glass between the two metallic coatings of the Leyden jar.

In Wilcke's treatise, alluded to below, he defines the two electricities much more clearly than had previously been done. He distinguishes three causes of excitation, viz. *warming, liquefaction* and *friction*; the *spontaneous electricity* already alluded to, he further says, is the result of the apposition or mutual action of two bodies, in consequence of which one of them is electrified positively and the other negatively; *communicated electricity*, on the other hand, is that which is superinduced upon the whole or part of a body, electric or non-electric, without the body having been previously heated, melted or rubbed, or without any mutual action between it and any other body. This distinction is, in general, very obvious, but Mr. Wilcke defines it throughout his work in a very clear manner, citing cases wherein they are frequently confounded.

Wilcke and Anton Brugmans (A.D. 1778) first propounded the theory of two magnetic fluids, which was afterward established by Coulomb (A.D. 1785) and perfected by the great mathematician Poisson (A.D. 1811). The hypothesis of the two fluids supposes that a magnet contains minute invisible particles of iron, each of which possesses by itself the properties of a separate magnet. It is assumed that there are two distinct fluids—the *austral* and the *boreal*—which reside in each particle of iron. These fluids are inert and neutral when combined, as in ordinary iron, but when they are

decomposed the particles of the *austral* attract those of the *boreal*, and *vice versa*, while they each repel one another.

REFERENCES.—Wilcke, "Disputatio inauguralis physica," etc., published Rostock, 1757, also his "Herrn Franklin's briefe von der electricitat," etc., Leipzig, 1758, his "Jal om Magneten," 1764, and his "Über den Magneten," Leipzig, 1758; besides 1794–1795; likewise his different Memoirs in the "Swedisches Musæum," Vol. I. p. 31, and in both the "Schwedischen Akad. Abhandlungen," etc. (also *Neue Abhand.*) and the "Vetensk Acad. Handl." for 1758, 1759, 1761–1763, 1766–1770, 1772, 1775, 1777, 1780, 1782, 1785, 1786, 1790; "The Electrical Researches of Hon. Hy. Cavendish," 1879, No. 134.

A.D. 1759.—Hartmann (Johann Friedrich), of Hanover, is the author of three works on electricity, published in that city during 1759, 1764 and 1766, wherein he gives an account of several very curious electrical experiments. One of the most interesting of these demonstrates the progressive motion of the electrical discharge. When he passes the shock through many small cannon balls, sometimes to the number of forty, placed upon small drinking goblets close by one another, all the sparks are seen and all the cracklings are heard at the same moment; but when he substitutes eggs (preferably ten or twelve) for the balls, the progress of the explosion is visible, every two giving a flash and a report separately.

He remarks that upon one occasion, as he re-entered a room which he had just before left, after making therein a number of experiments, he observed a small flame following him as he walked about swiftly while holding a lighted candle in his hand. The flame vanished whenever he stopped to examine it, and he attributed its appearance to the presence of sulphur thrown into the air by continued violent electrification.

REFERENCES.—Hartmann, "Abhandlung von der verwandschaft," etc., Hanover, 1759, pp. 58, etc., and 135; also his "Electrische experimente," etc., Hanover, 1766, and his "Anmerkungen," etc., 1764, 4to, p. 38; Friedrich Saxtorph, "Elektricitätsläre," Vol. II; *Hamburgisches Magazin* (also *Neues Hamb. Mag.*) for 1759, Vol. XXIV, and for 1761, Vol. XXV; "Nov. Acta Acad. Nat. Curios," Vol. IV. ss. 76–82, 126; "Göttingischen gemein. Abhand.," von Jahr 1775.

A.D. 1759.—Wesley (John), the founder of Methodism (1703–1791) and the most eminent member of a very distinguished English family, publishes "The Desideratum; or Electricity made Plain and Useful, by a Lover of Mankind and of Common-sense." In this, he relates at great length the cures of numerous physical and moral ailments, attributed to the employment of the electric fluid, under such curious headings as "Electricity, the Soul of the Universe," "Electricity, the Greatest of all Remedies," etc. ("The Library of Literary Criticism," C. W. Moulton, Buffalo, 1901–1902, Vol. IV. pp. 110–129).

A.D. 1759.—Æpinus (Franz Maria Ulrich Theodor) (1724–1802), celebrated German natural philosopher, member of the Scientific Academies of Berlin and St. Petersburg, publishes in the latter city his most important work, "Tentamen Theoriæ Electricitatis et Magnetismi," wherein he adopts, as did Wilcke, all the general principles of Franklin's theory of positive and negative electricities. Therein he also shows that the phenomena of electricity depend mainly upon the tendency of the fluid to attain a state of equilibrium by passing from bodies containing an excess to others which have less than the natural quantity; that the electric fluid existing in the pores of all bodies moves without obstruction in non-electrics and with much difficulty in electrics; that all bodies contain a fluid whose particles mutually repel one another with forces decreasing as the distance between them increases, and, according to the same law, attract the particles of the bodies with which they are in combination.

It has already been shown that, in conjunction with Wilcke, he found the means of charging a plate of air. This experiment, suggested by some of the observations made by Canton and Franklin, led to what may be considered one of the greatest discoveries in the science of electricity, for in this was first demonstrated the grand principle of induction (see Grey at A.D. 1720), and the result led to Volta's discovery of the *electrophorus*. Volta, also, was the first to apply to an electrometer the apparatus invented by Æpinus for condensing electricity.

Æpinus first discovers to its fullest the affinity existing between electricity and magnetism, explaining nearly all the phenomena of magnetism ("De Similitudine vis electricæ et magneticæ"; "Similitudinis effectuum vis magnet. et. elect. : novum specimen" in the "Novi Comment. Acad. Petrop.," Vol. X. p. 296). He improves upon the methods employed by both Duhamel and Michell for the construction of artificial magnets in a different line from that employed by John Canton, A.D. 1753. He lays the bar to be magnetized upon the ends of the opposite poles of two powerful field magnets, and places two bunches of magnetic bars upon the middle of the bar, separating the bunches by a piece of wood and keeping together the poles of each of the same name as that of the powerful fixed magnet nearest to it. These two bunches are then held at an inclination of 15 to 20 degrees, and are drawn away from each other to the end of the bar which is to be magnetized, so that each half of the bar receives the same number of strokes. When the bar is very thick, the process should be repeated upon its reverse, and in order to make the result more effective, the united ends of the bars should at the outset be

ground together, and pressure should be applied while the operation is going on.

Æpinus was the first to discover the polarity of the tourmaline. After M. Lechman acquainted him with its attractive power, he made many experiments, of which he communicated the very important results, during the year 1756, to the Academy of Sciences and Belles-Lettres at Berlin. Up to this time but little was known regarding the necessity of heat to excite the tourmaline. Æpinus found that he could electrify it to a high degree by placing the stone in boiling water, and that it was necessary to heat it to between 99½ degrees and 212 degrees Fahrenheit to develop its attractive powers. One of the extremities of the tourmaline terminated by the six-sided pyramid then becomes charged with positive electricity, while the other extremity is negative. When the stone is of considerable size, flashes of light can be seen along its surface.

M. De Romé Delisle, in his "Essai de Cristallographie," Paris, 1772, p. 268, alludes to what has already been stated relative to the necessity of heating the tourmaline (see J. G. S. at A.D. 1707, and Leméry at A.D. 1717), and he gives an extract from the work attributed to Adanson, as mentioned at A.D. 1751. Delisle's references embrace: "Act. Paris," 1717, p. 9; "Act. Berolin," 1756, p. 105; "Lettre du Duc de Noya Caraffa à M. de Buffon," Paris, 1759; *Ascendrecker, Aschentrecher, Aschenzicher* (*tire-cendre*), "Trip: Tourmaline, Vog. min." 191; "Act. Holmens," 1768, p. 7; besides, at pp. 209, 233 and 245 he speaks of the electrical and phosphorescent properties of crystals, showing that the *lapis lyncurius* of the ancients is the hyacinth or zircon of to-day (see B.C. 321), and not, as many believe, either amber or belemnite (*pierre de foudre, lapis fulminaris*), while the hyacinth of old was a purple stone which, if now found, would be classed among the amethysts.

REFERENCES.—"Allgemeine Deutsche Biographie," Leipzig, 1875, Vol. I. p. 129; Æpinus, "Sermo Acad. de similitudine," etc., 1758, and his "Recueil . . . sur la tourmaline," 1762; "Novi. Com. Petropol.," for 1761, 1764, 1768; "Acta Acad. Moguntinæ," Vol. II. p. 255; Leithead, "Electricity," p. 289; *Phil. Trans.*, Vol. LI. p. 394, and Vol. LVII. part i. p. 315; "Encycl. Brit.," articles "Electricity" and "Magnetism"; Bigeon's report in the "Annales de Ch. et de Phys.," 2e série, Tome XXXVIII. p. 150; Van Swinden, "Recueil," etc., La Haye, 1784, Vols. I and II *passim*; Becquerel in *Annales de Chimie et de Physique*, Vol. XXXVI. p. 50; Thomson, "Hist. Roy. Soc.," 1812, p. 184; "The Electrical Researches of the Hon. Henry Cavendish," Cambridge, 1879, Nos. 1, 134, 340 and 549; Lord Kelvin (Sir Wm. Thomson), "Æpinus atomized," in *Phil. Mag.* for March 1902, p. 257, etc., and in *Journal de Physique* for Sept. 1902, p. 605.

A.D. 1759.—Symmer (Robert) assails the theory announced by Dufay (see Franklin, A.D. 1752), and shows, in a paper submitted to the Royal Society, December 20, 1759, that all the electrical

phenomena are produced by two distinct but coexistent fluids not independent of, but counteracting each other. He says that equal quantities of these fluids are contained in all bodies while in their natural condition; that when a body is positively electrified it does not hold a larger share of electric matter, but a larger portion of one of the active powers, and when negatively electrified a larger portion of the other, and not, as Franklin's theory supposes, an actual deficiency of electric matter. Symmer's theory is perhaps best explained in his own words, as follows: "It is my opinion that there are two electric fluids (or emanations of two distinct electric powers), essentially different from each other; that electricity does not consist in the efflux and afflux of these fluids, but in the accumulation of the one or the other in the body electrified; or, in other words, it consists in the possession of a larger portion of the one or of the other power than is requisite to maintain an even balance within the body, and lastly, that according as the one or the other power prevails, the body is electrified in one or the other manner."

Very curious reading may be had by reference to the volumes of the *Philosophical Transactions* named below, in which Symmer details many experiments with pieces of silk, as well as with white and coloured, new and newly cleansed silk and worsted stockings. Therein he shows his ability to charge the Leyden jar with either positive or negative electricity, according as he presents a black or white stocking to the wire of the phial. These experiments, which Symmer admits to have made for the express purpose of proving the existence of two electricities, further illustrate the phenomenon of electrical cohesion, although the latter is still better demonstrated by means of panes of ordinary glass. He thus expresses himself: "Upon these considerations, we may expect, from the experiment in hand, the means of determining whether the distinction of electricity into two different kinds is merely nominal, or if there is an essential difference between them; for, after the glass plates have been electrified in one position, so as to be incapable of receiving any more electricity, if they be inverted, and in that new position presented to the chain and wire, and the globe again be put in motion, according as one or other of those opinions hold, corresponding effects will follow."

Symmer also proves his two distinct powers of electricity by the experiment of passing the electric shock through a quire of paper instead of through a single card ("Lib. Useful Knowledge," London, 1829, "Electricity," p. 44).

References.—"Electricity in the Service of Man," R. Wormell, London, 1900, p. xiv; *Philosophical Transactions*, Vol. LI. part i. pp. 171, 340, 366, 373, etc., 389, and Vol. LVII. p. 458; also Hutton's

abridgments, Vol. XI. p. 405; Nollet, "Lettres," etc., Vol. III. p. 42; "Encycl. Brit.," article "Electricity"; "Library of Useful Knowledge," London, 1829, "Electricity," Nos. 160 and 161.

A.D. 1760.—Mayer (Johann Tobias, Sen.) (1723–1762), one of the most celebrated German astronomers, director of the observatory at Göttingen, is the first to make known the law of the inverse square resulting from actual experimental investigation. This he does in a paper, "Inclination and Declination of the Magnetic Needle, as deduced from theory," read before the Royal Society at Göttingen, wherein he states that the intensities of the magnetic attractions and repulsions vary inversely as the squares of the distances from the pole of a magnet. Consult "Magnetism," in the ninth edition of the "Encyclopædia Britannica," for additional reference to the above paper, also section 14 of the same work for an account of Mayer's dipping needle as constructed by General Sabine.

References.—Delambre's notice of the life of J. T. Mayer in the "Biographie Universelle"; Hutton's "Mathem. Dict."; Montucla, "Histoire des Mathématiques"; list of his works added to the éloge pronounced by Kaestner, Göttingen, 1762; "Abhandlungen von Galvani und andern," Prague, 1793; Whewell, "History of the Inductive Sciences," 1859, Vol. II. pp. 206, 221; Coulomb, "Mémoires Acad. Paris" for 1786 and 1787; "Royal Soc. Cat. of Sc. Papers," Vol. IV. pp. 311–314; Lambert, "Reports of the Berlin Academy" for 1776.

Mayer (Johann Tobias, Jr.), 1752–1830, is the author of Memoirs on the magnetic needle as well as upon many electrical experiments, of which details may be found in the *Journal der Physik* of Friedrich A. C. Gren and in the "Comment Soc. Göttingen recent."

A.D. 1760.—Delaval (E. H.) communicates between 1760 and 1764 several papers to the London Royal Society in reference to experiments made for the purpose of ascertaining the conducting powers of a body in different states. Therein, he shows that animal and vegetable substances lose their conducting powers when reduced to ashes, and that while metals are the best conductors, their oxides are non-conductors. His experiments made with *island* (Iceland) *crystal* (well known for its extraordinary property of double refraction), proved that it is affected by heat differently from other substances named, since the temperature necessary to render them electric makes the crystal non-electric. He had a piece of crystal of which, he said, one part became non-electric when greatly heated, while the other part, with the same or even a much greater heat, remained perfectly electric. These experiments did not, however, succeed with Sir Torbern Bergman, who repeated them with great care and who found that *island crystal* was a conductor in all cases, to whatever degree of heat it was exposed.

REFERENCES.—*Phil. Trans.*, Vol. LI. part i. p. 83; Vol LII. part i. pp. 353, etc., and part ii. p. 459; also Vol. LIII. part i. pp. 84–98; and Hutton's abridgments, Vol. XI. pp. 334, 589; Vol. XII. p. 140; Thomas Thomson, "Hist. of Roy. Soc.," p. 443; Thos. Young, "Course of Lectures," 1807, Vol. II. p. 679, for notes on Dr. Wm. H. Wollaston's paper concerning the double refraction of Iceland crystal.

A.D. 1760–1762.—Bergman—Bergmann—(Torbern Olof), celebrated Swedish astronomer, naturalist and chemist, writes several letters to Mr. Wilson, which are read before the Royal Society, Nov. 20, 1760, and March 18, 1762, wherein he alludes to the possibility of electrifying plates of ice in the same manner as plates of glass. In a subsequent letter he details experiments with silk ribbons of different colours, almost as curious as those of which an account has already been given (by Symmer at A.D. 1759), and from which he concludes that there is a certain fixed order regarding positive and negative electricity in which all bodies may be placed while other circumstances remain unchanged.

REFERENCES.—Bergman's "Bemerkung . . . Isländischen Krystales," "Comment . . . electrica turmalini," "Elektrische Versuche," etc., and his other works referred to in the *Philosophical Transactions*, Vol. LI. p. 907; Vol. LIII. p. 97; Vol. LIV. p. 84; Vol. LVI. p. 236; also Hutton's abridgments, Vol. XI. pp. 506, 705; Vol. XII. pp. 109, 343; "Nova Acta Soc. Upsal.," "K. Schwedischen Akad. Abhand.," "Aus dem Schwed. Magazine," *Phil. Mag.*, IX. p. 193; "Eng. Cycl.," Vol. I. pp. 664–665; Gmelin's "Chemistry," Vol. I. p. 320; Thomas Thomson, "Hist. of the Royal Society," London, 1812, pp. 444, 475–477.

A.D. 1761.—The many experiments made at this period by Ebenezer Kinnersley, of Philadelphia, relative to the two contrary electricities of glass and sulphur, are endorsed by his close friend Benjamin Franklin in his *Letters* at pp. 99, 100 and 102–105. He makes several curious observations on the elongation and fusion of fine iron wires whenever a strong charge is passed through them while in a state of tension, to which Dr. Watson makes special reference in a paper read before the Royal Society. He believes that lightning does not melt metal by a cold fusion, as Dr. Franklin and himself had formerly supposed, and that when it passes, for instance, through the blade of a sword, if the quantity is not very great, it may heat the point so as to melt it, while the broadest and the thickest part may not be sensibly warmer than before.

To ascertain the effects of electricity upon air, Kinnersley devised an instrument which he called an *electrical air thermometer*, and which is described at p. 626, Vol. VIII of the 1855 "Encyclopædia Britannica." With this he could show the sudden rarefaction which air undergoes during the passage of the electric spark through it,

heat being produced without accompaniment of any chemical change in the heated body.

Some other important observations made by Kinnersley, who, besides being an intimate friend, was the original associate of Ben. Franklin, are summed up as follows: A coated flask containing boiling water cannot be charged, the electricity passing off with the steam; but when the water gets cold the flask may be charged as usual. A person in a negative state of electricity standing upon an electric, and holding up a long sharp needle out of doors in the dark, observes light upon the point of it. No heat is produced by electrifying a thermometer, nor by passing shocks through large wire, but small wire is heated red-hot, expanded and melted (*Phil. Trans.* for 1763, Vol. LIII. p. 84; Thomson, "Hist. Roy. Soc.," p. 445).

In the New York "Electrical Review" of May 13, 1905, will be found the following curious reference to the Boston Art Club exhibits of President R. H. W. Dwight:

"Among these is an interesting broadside, which gives a summary of two lectures on electricity by Ebenezer Kinnersley delivered in Faneuil Hall in September, 1751—the first lectures probably ever delivered on the then new subject of electricity. Kinnersley was an Englishman, who was head master in English literature in the College of Philadelphia, from 1753 to 1773, a student of science, who made a number of discoveries in electricity and invented a number of quaint electrical devices. He and Franklin were on intimate terms, and were closely associated in their electrical experiments. Kinnersley has been erroneously cited as an anticipator of Oersted's discovery of the deflection of a magnetic needle by an electric current. The former's experiment, however, was purely electrostatic. In the summary of these two lectures, among other things, it states that electricity 'is an extremely subtile fluid; that it doth not take up any perceptible time in passing through large portions of space; that it is mixed with the substance of all other fluids and solids of our globe; that our bodies at all times contain enough of it to set a house on fire.'"

The exhibits of President Dwight are:

"An artificial spider animated by the electric fire so as to act like a live one; a shower of sand which rises again as fast as it falls; a leaf of the most mighty of metals suspended in the air, as is said of Mahomet's tomb; electrified money which scarce anybody will take when offered to them; a curious machine, acting by means of the electric fire, and playing a variety of tunes on eight musical bells."

This broadside of 1751 appears to antedate any other similar notice of electrical experiments.

The "Electrical Review" of April 23, 1904, p. 621, had published copy of an advertisement from the Massachusetts *Gazette* of March 7, 1765, giving notice of a course of lectures by David Mason, illustrated by "entertaining experiments on electricity similar to those cited in the broadside under date of 1751." The advertisement of 1765, here referred to, appears at A.D. 1771.

REFERENCES.—Sturgeon's "Lectures," London, 1842, p. 169; "The Electrical Researches of Hon. Henry Cavendish," 1879, Nos. 125, 137, 213; *Phil. Trans.*, Vol. LIII. part i. pp. 84–87; Vol. LIV. p. 208; Vol. LXIII, 1773, part i. p. 38; also the Hutton abridgments, Vol. XI. p. 702, and Vol. XIII. p. 370; Bertholon, "Elec. du Corps Humain," 1786, Vol. I. pp. 23, 33, 214, 217, 220.

A.D. 1762.—Sulzer (Johann Georg), a Swiss philosopher, member of the Berlin Academy of Sciences, in his "Theory of Agreeable and Disagreeable Sensations" ("Theorie d. angenehmen u. unangenehmen Empfindungen," Berlin, 1762), thus expresses himself: "When two pieces of metal, one of lead and the other of silver, are so joined together that their edges make one surface, a certain sensation will be produced on applying it to the tongue, which comes near to the taste of martial vitriol (vitriol of iron); whereas each piece by itself betrays not the slightest trace of that taste" (F. C. Bakewell, "Manual of Electricity," London, 1857, Chap. III. p. 28).

The passage in the edition "Nouvelle Théorie des Plaisirs," published in 1767, is thus given by Sabine, "Electric Telegraph," 1872, p. 15: "On taking two pieces of different metals—silver and zinc—and placing one of them above and the other underneath his tongue, he found that, so long as the metals did not make contact with each other, he felt nothing; but that when the edges were brought together over the tip of his tongue, the moment contact took place and during the time it lasted, he experienced an itching sensation and a taste resembling that of sulphate of iron. . . ." Sulzer does not appear to have been much surprised at the result, thinking it "not improbable that, by the combination of the two metals, a solution of either of them may have taken place, in consequence of which the dissolved particles penetrate into the tongue; or we may conjecture that the combination of these metals occasions a trembling motion in the respective particles, which, exciting the nerves of the tongue, causes that peculiar sensation."

And thus, remarks Pepper, a prominent fact has slept in obscurity from the time of Sulzer to the time of Galvani.

REFERENCES.—Izarn, "Manuel," Paris, 1804, p. 4; Sturgeon, *Annals*, Vol. VIII. p. 363; also note at p. 491 of Ronalds' "Catalogue"; *Mém. de l'Acad. de Berlin*, "Théorie Générale du Plaisir"; also "Temple

du Bonheur," published at Bouillon (Pays Bas), 1769, Tome III. p. 124, this last-named work being alluded to in the *Journal des Débats*, 7 Vendémiaire, au X; Edm. Hoppe, "Geschichte," 1884, p. 128; C. H. Wilkinson, "Elements of Galvanism," Vol. I. p. 69, note; Albert's "Amer. Ann. d. Artz," Vol. II. Bremen, 1802.

A.D. 1762. — Ledru Comus, French Professor of Natural Philosophy, invents a mode of telegraphing which is described and fully illustrated in Vol. I of Guyot's "Nouvelles Récréations Physiques et Mathématiques," Paris, 1769; as well as at p. 278 of "Mémoires, Correspondance et Ouvrages Inédits de Diderot," Paris, 1821, in one of the letters to Mlle. Voland dated July 28, 1762.

His apparatus consisted of two dials, each bearing upon it twenty-five letters of the alphabet, which were moved by the agency of magnets and of magnetized needles; but Auguste Guérout considers the contrivance to have been merely a speculative one, as will be seen by his article, reproduced from "La Lumière Electrique" of March 3, 1883, in No. 384 of the "Scientific American Supplement."

References.—*Journal de Physique* for 1775, Vols. V and VI; for 1776, Vol. VII; and for 1778, Vol. I; "Scelta di Opuscoli," Milano, 1776.

A.D. 1765.—Cigna (Giovanni Francesco), native of Mondovi, Italy, and nephew to the electrician Beccaria (A.D. 1753), became secretary to the society of savants who gave birth to the Royal Academy of Sciences at Turin, and whose Memoirs contain his work, "De novis quibusdam experimentis electricis," 1765.

At pp. 31–65 of the above Memoirs is given a full account of Cigna's many curious observations made with silk ribbons placed in various positions, and in contact with different surfaces, instead of with the silk stockings employed by Symmer (A.D. 1759). He thus supplies the main defect of Dufay's theory (A.D. 1733) by proving that the two opposite electricities are produced simultaneously. On p. 47 of the same work will be found a report of Cigna's experiment with ice to ascertain whether electric substances contain more electric matter than other bodies.

References.—Vol. III. p. 168 of Nollet's "Letters," for an account of his observations upon the electric attraction and repulsion between conducting substances immersed in oil; as well as Chap. II. s. 3., vol. i. of Van Swinden's "Receuil," etc., published at La Haye, 1784. Should also be consulted: Cigna's "Memoirs on Electricity and Magnetism" in the "Miscellanea . . . Taurinensia," and the several communications made by him to Priestley, Lagrange and others in 1775 concerning Volta's electrophorus; likewise "Memorie istorische . . . di Gianfrancesco Cigna de Antonmaria Vassalli Eandi," Torino, 1821.

A.D. 1766–1776.—Lambert (Johann Heinrich), a profound German mathematician, native of Upper Alsace, publishes in

Vol. XXII of the "Reports of the Berlin Academy" two beautiful Memoirs upon the "Laws of Magnetic Force" and upon the "Curvature of the Magnetic Current," both of which, according to Dr. Robison, would have done credit to Newton himself.

In the first Memoir, says Harris, the author endeavours to determine two very important laws; one relating to the change of force as depending upon the obliquity of its application, the other as referred to the distance. In the second Memoir the curves of the magnetic current are investigated by the action of the directive or polar force of a magnet upon a small needle. Lambert concludes that the effect of each particle of the magnet on each particle of the needle, and reciprocally, is as the absolute force or magnetic intensity of the particles directly, and as the squares of the distances inversely.

Noad states ("Manual," London, 1859, p. 580) that Lambert's deductions were confirmed twenty years later by Coulomb, through the agency of his delicate torsion balance, and more recently (about the year 1817) by Prof. Hansteen, of Christiania.

Previous to the above-named date, in 1760, Lambert had published, both at Leipzig and at Augsburg, his "Photometria, sive de Mensura et Gradibus Luminis, Colorum et Umbræ," the sequel to a tract printed two years before, wherein he indicates the mode of measuring the intensity of the light of various bodies. The celebrated mathematician and astronomer, Pierre Bouguer (1698–1758), who had published, in 1729, his "Essai d'Optique," etc., which was greatly enlarged in his "Traité," etc., brought out by La Caille in 1760, may be considered the founder of this branch of the science of optics, to which the name *photometry* has been given by English writers. The photometer designed by Sir Benjamin Thompson, *Count Rumford* (entered at A.D. 1802), has been described in *Phil. Trans.* for 1794, Vol. LXVII. His method is to cast two shadows of a given object near each other on the same surface, the lights being removed to such distances that the shadows appear equally dark.

References.—Sir John Leslie's "Fifth Dissertation" in the eighth "Encycl. Brit."; Count Rumford's photometer illustrated at Plate XXVII. figs. 387, 388, vol. i. of Dr. Thomas Young's "Course of Lectures," London, 1807; also Vol. II. pp. 282 and 351 of the same work, concerning photometry generally; Dredge and others, "Electric Illumination," etc. (chiefly compiled from London *Engineering*), Vol. II. pp. 101–117; Brewster's "Edin. Jour. of Sc.," 1826, Vol. II. p. 321; Vol. III. p. 104; Vol. V. p. 139, for William Ritchie's articles on the photometer of Mr. Leslie, and relative to an improved instrument upon the principles of Bouguer (*Edin. Transactions*, Vol. X. part. ii.); Lambert's biography and the article "Magnetism" in the "Encycl. Brit."; Harris, "Rudim. Magn.," Part III. pp. 20, 33, 191–203.

It may be added that all the valuable manuscripts left by

Lambert were purchased by the Berlin Academy, and were afterward published by John Bernoulli, a grandson of the celebrated John Bernoulli alluded to at A.D. 1700.

A.D. 1766.—Lullin (Amadeus), in his "Dissertatio physica de electricitate," Geneva, 1766, at p. 26, alludes to Beccaria's experiments, saying that he produced much greater effects with the electric spark by passing the latter through oil instead of water: oil being a much worse conductor, the spark in it is larger. At p. 38 of the same work he details the experiments made to prove the correctness of Mollet's doctrine regarding the constant motion of electrical atmospheres, and at p. 42 are given his experiments to show the production of electricity in the clouds. With a long insulated pole projecting from the mountain side he observed, among other effects, that when small clouds of vapour produced by the sun's heat touched only the end of the pole the latter was electrified, but that it was not affected if the entire pole was covered by the vapour ("Lib. Useful Knowledge," "Electricity," Chap. XI. Nos. 154, etc.).

Lullin, it is said, proposed a modification of Reusser's plan of telegraphing, in manner stated at p. 69 of Reid's 1887 "Telegraph in America."

A.D. 1766.—L'Abbé Poncelet, a native of Verdun, France, publishes at Paris "La Nature dans la formation du Tonnerre," etc., wherein he indicates a method of protecting from lightning residences, pavilions and other structures, by constructing them of resinous woods and lining them with either silk or waxed cloths. He quaintly remarks that as they thus present "on all sides resinous surfaces, which never receive phlogiston by communication, the latter (thunder and lightning), after having leaped lightly around the pavilion and finding itself unable to attack it, will probably depart in order to pursue its ravages elsewhere."

References.—*Scientific American Supplement*, No. 66, p. 1053, for a copy of the frontispiece of the above-named work; also Figuier, "Exposition et Histoire," etc., 1857, Vol. IV. pp. 234, 235.

A.D. 1767.—Bozolus (Joseph), an Italian Jesuit, Professor of Natural Philosophy at Rome, is the first (and not Cavallo, A.D. 1775) to suggest employing the active principle of the Leyden jar for the transmission of intelligence.

His plan is to place underground two wires which are to be brought at each station close enough to admit of the passage of a spark. One of the wires is to be connected with the inner coating and the other with the outer surface of a Leyden phial; the sparks

observed at the opening between the wires being there made to express any meaning according to a preconcerted code of signals.

REFERENCES.—Latin poem entitled "Mariani Parthenii Electricorum," in six books, Roma, 1767, lib. i. p. 34 (describing the *telegrafo elettrico scintillante*); also *Saturday Review*, August 21, 1858, p. 190, and *Cornhill Magazine* for 1860, Vol. II. p. 66.

A.D. 1767.—Priestley (Joseph), the earliest historian of electrical science, publishes, by advice of Benjamin Franklin, the first edition of his great work, "The History and Present State of Electricity," of which there were four other separate enlarged issues, in 1769, 1775, 1775 and 1794. During the year 1766 he had been given the degree of Doctor of Laws by the Edinburgh University and he had also, at the instance of Franklin, Watson and others, been made a member of the English Royal Society, which, a few years later, bestowed upon him the Copley medal.

Speaking of the above-named work, Dr. Lardner says (" Lectures, 1859, Vol. I. p. 136): "This philosopher did not contribute materially to the advancement of the science by the development of any new facts; but in his 'History of Electricity' he collected and arranged much useful information respecting the progress of the science." Nevertheless, to him is due the first employment of the conductor supported by an insulating pillar, as described by Noad, who gives an account of Priestley's electrical machine at Chap. IV of his "Manual"; and he is also the first to investigate upon an extensive scale the chemical effects of ordinary electricity. The observations of M. Warltire, a lecturer on natural philosophy, and Priestley's own experiments in this line, made by passing the electric spark through water tinged blue by litmus, also through olive oil, turpentine, etc., as well as his researches more particularly upon the gases and upon the influence of the electric fluid in expanding solid bodies, are detailed at the "Electricity" chapter of the "Encycl. Brit."

At pp. 660–665 of the fourth edition of his "History," Priestley describes the experiments he made to illustrate what he called the *lateral force of electrical explosions*; that is, the tendency of the fluid to diverge, as is the case with lightning when any material obstruction lies in its path.

Perhaps the most important of all Dr. Priestley's electrical discoveries (Thomson, "Hist. Roy. Soc.," p. 445) was that charcoal is a conductor of electricity, and so good a conductor that it vies even with the metals themselves. When the conducting power of charcoal was tried by succeeding electricians, it was found to vary in the most unaccountable manner, sometimes scarcely conducting at all,

sometimes imperfectly and sometimes remarkably well; a diversity naturally indicating some difference in the nature of the different specimens of English charcoal (Priestley's "History," etc., Part VIII. s. 3). Charcoal being examined by Mr. Kinnersley (at A.D. 1761), was also by him observed to vary in its conducting power. Oak, beech and maple charcoal he found to conduct satisfactorily; the charcoal from the pine would not conduct at all, while a line drawn upon paper by a heavy black lead pencil conducted pretty well (*Phil. Trans.*, 1773, Vol. LXIII. p. 38).

REFERENCES.—Priestley's letter to Dr. Franklin (*Phil. Trans.*, Vol. LXII. p. 360) concerning William Henley's new electrometer and experiments; likewise the *Phil. Trans.*, Vol. LVIII. p. 68; Vol. LIX. pp. 57, 63; Vol. LX. p. 192; Vol. LXII. p. 359; and the abridgments by Hutton, Vol. XII. pp. 510, 600, 603; Vol. XIII. p. 36; "Trans. of the Amer. Phil. Soc.," O. S., Vol. VI. part i. p. 190, containing proceedings of the Society on the death of Joseph Priestley; Wilkinson's "Elements of Galvanism," etc., London, 1804, Vol. II. pp. 74–80; Noad's Lectures, No. 4, Knight's edition, pp. 182, 183; "Library of Useful Knowledge," London, 1829, Chap. "Electricity," pp. 41 and 45; "Library of Literary Criticism," C. W. Moulton, Buffalo, 1901–1902, Vol. IV. pp. 444–456; "Essays, Reviews and Addresses" by James Martineau, London, 1890, Vol. I. pp. 1–42; "Mém. de l'Institut" (Histoire), Tome VI. 1806, p. 29 for Elogium; "Essays in Historical Chemistry," T. E. Thorpe, London, 1894, pp. 28, 110; "Science and Education," by Thos. Henry Huxley, New York, 1894, pp. 1–37; "Scientific Correspondence of Jos. Priestley," by H. C. Bolton, New York, 1902; Dr. Thos. H. Huxley, "Science Culture," 1882, p. 102; Warltire, in Muirhead's translation of Arago's "Eloge de James Watt," pp. 99, 100; also the appendix to the last-named work, p. 157 and note.

A.D. 1767.—Lane (Thomas—Timothy), a medical practitioner of London, introduces his *discharging electrometer*, which is now to be found described and illustrated in nearly all works on electricity.

It consists of a bent glass arm, one end of which is attached to a socket in the wire of the Leyden jar, while the other end holds a horizontal sliding brass rod, or spring tube, which bears a ball at each extremity. The rod is usually divided into inches and tenths, indicating the force of the discharge which takes place when the knob of the jar is placed in contact with the prime conductor of an electrical machine, and the charge is strong enough to leap from one to the other. In Mr. Lane's experiments the shocks were twice as frequent when the interval between the balls was one twenty-fourth of an inch as when twice as much: from which he concluded that the quantity of electricity required for a discharge is in exact proportion to the distance between the surfaces of the balls.

A combination of the Lane and other electrometers was made by Mr. Cuthbertson, as shown at p. 528, Vol. II of *Nicholson's Journal of Natural Philosophy*, and at p. 451, Vol. LVII of the *Philosophical Transactions*.

REFERENCES.—*Phil. Trans.* for 1805; Hutton's abridgments, Vol. XII. p. 475; Cavallo, "Elements . . . Phil." 1825, Vol. II. p 197; Harris, "Electricity," p. 103; *Monthly Magazine*, December 1805, and *Tilloch's Philosophical Magazine*, Vol. XXIII. p. 253.

The Hutton abridgments contain, at p. 308, Vol. XV, the description of a new electrometer by Abraham Brook.

A.D. 1768.—Ramsden (Jesse), a very capable English manufacturer of mechanical instruments, member of the Royal Society and of the Imperial Academy of St. Petersburg, is said to be the first to construct an electrical machine wherein a plate of glass is substituted for the glass globe of Newton and of Hauksbee and for the glass cylinder of Gordon (at A.D. 1675, 1705 and 1742). The same claim which has been made for Martin de Planta, Swiss natural philosopher, appears to have no foundation. (See note at p. 401 of Ronalds' "Catalogue.")

REFERENCES.—*Journal des Sçavans*, November 1788, p. 744; *Phil. Trans.*, 1783; "Chambers' Encyclopædia," 1868, Vol. III. p. 812; Mme. Le Breton, "Hist. et app. de l'Electricité," Paris, 1884, pp. 61, 62.

A.D. 1768.—Molenier (Jacob), physician to the French King, Louis XV, writes "Essai sur le Mécanisme de l'Electricité" for the purpose of showing the utility of the application of the electric fluid in medical practice. At p. 60 he explains the effects and results when applications are made more particularly to the nerves, and at pp. 65–67 he gives certificates of many of the cures he has effected of gout, rheumatism, tumours, cancers, loss of blood, as well as of pains and aches of various descriptions.

REFERENCES.—Jallabert (A. D. 1749); Lovett (A.D. 1756); Bertholon (A.D. 1780–1781); Mauduyt (A.D. 1781); Van Swinden, "Recueil," etc., La Haye, 1784, Vol. II. pp. 122–129 for the experiments of Sauvages, De La Croix, Joseph Elder von Herbert, H. Boissier and others; Thomas Fowler, "Med. Soc. of London," Vol. III; M. Tentzel, "Collection Académique," Tome XI; the works of L'Abbé Sans, Paris, 1772–1778; M. de Cazèles Masar's "Mémoires et Recueils," published 1780–1788, and reproduced in Vols. II and III of the "Mémoires de Toulouse"; Jacques H. D. Petetin, "Actes de la Soc. de Lyon," p. 230; M. Partington, *Jour. de Phys.*, 1781, Vol. I; Dr. Andrew Duncan's "Medical Cases," Edinburgh, 1784, pp. 135, 191, 235, 320; C. A. Gerhard, "Mém. de Berlin," 1772, p. 141; *Jour. de Phys.*, 1783, Vol. II; J. B. Bohadsch, "Dissertatio," etc., Prague, 1751; *Phil. Trans.* for 1752; Patrick Brydone, *Phil. Trans.* for 1757; Geo Wilkinson, of Sunderland, "An account of good effects," etc., in *Medical Facts*, etc., 1792, Vol. III. p. 52; M. Carmoy, "Observ. sur l'El. Med.," Dijon, 1784; M. Cosnier, M. Maloet, Jean Darcet, etc.; "Rapport," etc., 1783; Le Comus, "Dissertatio," etc., 1761; Le Comus, "Osservazioni," etc., 1776 (*Jour. de Phys.*, 1775, Vols. V and VI; 1776, Vol. VII; 1778, Vol. I; 1781, Vol. II); Ledru, "Sur le traitement," etc., 1783; Le Dr. Boudet, "De l'Elec. en Médecine," conférence faite à Vienne le 6 Octobre, 1883.

A.D. 1769.—Bancroft (Edward Nathaniel), a resident physician of Guiana, openly expresses the belief that the shock of the *torpedo*

is of an electrical nature. He alludes (" Natural History of Guiana ") also to the *gymnotus electricus*, which, he says, gives much stronger strokes than the *torpedo ;* the shocks received from the larger animals being almost invariably fatal.

The discharge of the *gymnotus* has been estimated to be equal to that of a battery of Leyden jars of three thousand five hundred square inches, fully charged. At a later date, the American physicians, Garden and Williamson, showed that as the fluid discharged by that fish affects the same parts that are affected by the electric fluid; as it excites sensations perfectly similar; as it kills and stuns animals in the same manner; as it is conveyed by the same bodies that carry the electric fluid and refuses to be conveyed by others that refuse to take the fluid, it must be the electric fluid itself, and the shock given by the eel must be the electric shock.

Humboldt, speaking of the results obtained by M. Samuel Fahlberg, of Sweden, says : " This philosopher has seen an electric spark, as Walsh and Ingen-housz had done before him at London, by placing the *gymnotus* in the air and interrupting the conducting chain by two gold leaves pasted upon glass and a line distant from each other" (*Edinburgh Journal,* Vol. II. p. 249). Faraday, who gives this extract at paragraph 358 of his " Experimental Researches," says he could not, however, find any record of such an observation by either Walsh or Ingen-housz and does not know where to refer to that by Fahlberg. (See the note accompanying aforenamed extract.)

References.—*Annales de Chimie et de Physique,* Vol. XI; *Phil. Trans.* for 1775, pp. 94, 102 (letter of Alexander Garden, M.D.), 105, 395; " Acad. Berlin," 1770, 1786; fifteenth series Faraday's " Exper. Researches," read December 6, 1838; Wheldon's " Catalogue," No. 74, 1870; Sir David Brewster's " Edin. Jour. of Science," 1826, Vol. I. p. 96, for the observations of Dr. Robert Knox; G. W. Schilling: at Ingen-housz, " Nouvelles Expériences," p. 340, as well as at note, p. 439, Vol. I. of Van Swinden's " Recueil," etc., La Haye, 1784; also G. Schilling's " Diatribe de morbo in Europâ penè ignoto," 1770; article " Physiology " in the " Encycl. Brit.," 1859, Vol. XVII. p. 671; Aristotle (B.C. 341), Scribonius (A.D. 50), Richer (A.D. 1671), Redi (A.D. 1678), Kaempfer (A.D. 1702), Adanson (A.D. 1751); *Sc. Am. Suppl.,* No. 24, p. 375 (for M. Rouget's observations on the *gymnotus*) and No. 457, p. 7300; M. Bajon, " Descrizione di un pesce," etc., Milano, 1775 (*Phil. Trans.,* 1773, p. 481); M. Vanderlot's work on the Surinam eel, alluded to at p. 88 of " Voyage Zoologique," by Humboldt, who published in Paris, during 1806 and also during 1819 special works on the *gymnotus* and upon electrical fishes generally.

A.D. 1769.—Cuthbertson (John), English philosophical instrument maker, issues the first edition of his interesting work on electricity and galvanism.

He is the inventor of the *balance electrometer,* employed for regulating the amount of a charge to be sent through any substance,

as well as of an electrical condenser and of an apparatus for oxidating metals, all of which are respectively described at pp. 593, 614 and 620, Vol. VIII. of the 1855 " Encycl. Brit."

At the end of Part VI of his " Practical Electricity and Galvanism," Cuthbertson gives the conclusions he reached from his numerous experiments with wire. These, as well as Mr. George Adams' own observations (" Essay," etc., 1799, p. 285), proved that the quantity of electricity necessary to disperse a given portion of wire will be the same, even though the charged surface be greatly varied; and that equal quantities of electricity in the form of a charge will cause equal lengths of the same steel wire to explode, whether the jar made use of be of greater or less capacity (*Nicholson's Journal*, Vol. II. p. 217).

During his many experiments Cuthbertson made the very extraordinary discovery that a battery of fifteen jars and containing 17 square feet of coated glass, which, on a very dry day in March 1796 could only be made to ignite from 18 to 20 inches of iron wire of $\frac{1}{150}$ part of an inch in diameter, took a charge which ignited 60 inches when he breathed into each jar through a glass tube (Noad, " Manual," p. 122; also Cuthbertson, " Prac. Elec. and Magnetism," 1807, pp. 187, 188).

References.—Cuthbertson's communication to the " Emporium of Arts," Vol. II. p. 193, regarding his experiments on John Wingfield's " New Method of Increasing the Charging Capacity of Coated Electric Jars "; Cuthbertson's " Electricity," Parts VIII, IX and XI; Cuthbertson's letter addressed to *Nicholson's Journal*, Vol. II. p. 526, also *Phil. Mag.*, Vol. II. p. 251. for electrometers; " Bibl. Britan.," Vol. XXXIX. 1808, p. 97; Vol. XLVII. 1811, p. 233; Cuthbertson's several works published at Amsterdam and Leipzig, 1769–1797, and alluded to in *Phil. Mag.*, more particularly at Vols. XVIII. p. 358; XIX. p. 83; XXIV. p. 170; XXXVI. p. 259, as well as at p. 313, Vol. XII. of J B. Van Mons' *Journal de Chimie ; Nicholson's Journal*, Vols. II. p. 525; VIII. pp. 97, 205, and the New Series, Vol. II. p. 281 ; Gilbert's *Annalen*, Vol. III. p. 1; " Bibl. Brit. Sc. et Arts," Genève, 1808, Vol. XXXIX. p. 118; Noad's " Manual," p. 118; Van Marum (A.D. 1785); Harris, " Electricity," p. 103, and his " Frictional Electricity," p. 76; C. H. Wilkinson, " Elements of Galvanism," etc., London, 1804, Vol. II. pp. 242, 266–268; *Phil. Trans.*, 1782, for A. Brook's electrometer, which apparatus is described in the latter's work published, under the head of " Miscellaneous Experiments," at Norwich, 1789, as well as in the " Electricity " article of the " Encycl. Britannica."

A.D. 1769.—St. Paul's Cathedral, London, is first provided with lightning conductors. Dr. Tyndall, who mentions this fact (Notes of Lecture VI, March 11, 1875) likewise states that Wilson, who entertained a preference for blunt conductors as against the views of Franklin, Cavendish and Watson, so influenced King George III that the pointed conductors on Buckingham House were, during the year 1777, changed for others ending in round balls.

In 1772, St. Paul's Cathedral was struck by lightning, which "heated to redness a portion of one of its conductors consisting of a bar of iron nearly four inches broad and about half an inch thick." In 1764, the lightning had struck St. Bride's Church, London, and "bent and broke asunder an iron bar two and a half inches broad and half an inch thick" (Sturgeon, "Sc. Researches," Bury, 1850, p. 360; *Phil. Trans.* for 1764 and 1762).

The Rev. James Pilkington, Bishop of Durham, published in London a detailed account of the partial destruction of St. Paul's Church by lightning, June 4, 1561, which is also to be found at pp. 53–55 of Strype's "Life of Grindall," published in London, 1710, and of which an abstract appears under the A.D. 1754 date.

References.—Sturgeon's *Annals*, Vol. X. pp. 127–131; also, Biography of John Canton in "Encycl. Britannica"; Sir John Pringle, at A.D. 1777; Hutton's abridgments of the *Phil. Trans.*, Vol. XII. pp. 620–624.

A.D. 1769.—Mallet (Frederick) member of the Royal Society of Upsal and of the Stockholm Academy of Sciences, acting upon the observations of Anders Celsius (at A.D. 1740), is the first to make an attempt to determine the intensity of magnetism simultaneously at distant points. He ascertains that the number of oscillations in equal times at Ponoi, China (latitude, 67 degrees 4 minutes north; longitude, 41 degrees east) are the same as at St. Petersburg, Russia (59 degrees 56 minutes north latitude; 30 degrees 19 minutes east longitude).

References.—Walker, "Magnetism," Chap. VI; "Novi Commen. Acad. Sc. Petropol.," Vol. XIV for 1769, part ii. p. 33; Le Monnier, "Lois du Magnétisme," etc., 1776, p. 50; "Biog. Univ.," Vol. XXVI. p. 258.

A.D. 1770.—The well-known work of Jas. Ferguson, F.R.S., which first appeared under the title of "Introduction or Lectures on Electricity," now becomes still more popular under the head of "Lectures on Select Subjects," etc. (Consult likewise his "Lectures on Electricity," corrected by C. F. Partington, with appendix, London, 1825.)

In his first lecture he says that the most remarkable properties of the loadstone are: (1) it attracts iron and steel only; (2) it constantly turns one of its sides to the north and the other to the south, when suspended to a thread that does not twist; (3) it communicates all its properties to a piece of steel when rubbed upon it without losing any itself. He cites the experiments of Dr. Helsham, according to whom, says he, the attraction of the loadstone decreases as the square of the distance increases. He also treats of electrical attraction generally, and reports in the sixth lecture

having "heard that lightning, striking upon the mariner's compass, will sometimes turn it round and often make it stand the contrary way, or with the north pole towards the south."

A.D. 1770.—Hell—Hehl—Heyl—Höll (Maximilian), Hungarian scientist (1720–1792), member of the Order of Jesuits and Professor of Astronomy at Vienna, who had great faith in the influence of the loadstone, invented a singular arrangement of steel plates to which he afterward attributed the cure "with extraordinary success" of many diseases, as well as of a severe attack of rheumatism from which he himself had long suffered.

He communicated his discovery to Friedrich Anton Mesmer, who was so strongly impressed by Hell's observations that he immediately procured every conceivable description of magnet, with which he made many experiments that led to his introduction of animal magnetism, or rather *mesmerism.*

He is the author of many works, the most important being "Elementa Algebræ Joannis Crivelii magis illustrata et novis demonstrationibus et problematibus aucta," Vienna, 1745; "Observ. Astronomicæ," 1768, and "Auroræ Boreales Theoria nova," 1776.

References.—Beckmann, Bohn, 1846, Vol. I. p. 44; *Practical Mechanic*, Glasgow, 1843, Vol. II. p. 71; Van Swinden, "Recueil," etc., La Haye, 1784, Vol. II. pp. 303, 304, etc.; J. Lamont, "Handbuch," etc., p. 436; M. V. Burq, "Métallo thérapie," Paris, 1853; "Biog. Générale," Vol. XXIII. pp. 836–839; Schlichtegroll, "Nekrol.," 1792, Vol. I. pp. 282–303; "Journal des Sçavans," for July 1771, p. 499; Meusel, "Gelehrtes Teutschl"; Jer. de la Lande, "Bibliogr. Astronomique," Paris, 1803, pp. 721–722.

A.D. 1771.—Morveau (Baron Louis, Bernard Guyton de), a very prominent French chemist and scientist, publishes at Dijon his "Reflexions sur la boussole à double aiguille," and, later on, communicates to the *Annales de Chimie*, Vol. LXI. p. 70, and Vol. LXIII. p. 113, very valuable papers treating on the influence of galvanic electricity upon minerals, which are read before the French Institute.

References.—Thomson, "Hist. of Chemistry," Vol. II. 1831; the translation of Morveau's letter to Guénaud de Montbéliard in *Scelta d' Opuscoli*, Vol. XXXIII. p. 60; Berthollet, "Discours," etc., 1816; "Biog. Univ.," Tome XVIII. pp. 296–298; "Journal des Savants" for Jan. 1860; "Roy. Soc. Cat. of Sc. Papers," Vol. III. pp. 99–102; Vol. VI. pp. 679–680; "Biog. Univ. et Portative," etc., 1834, Vol. III. p. 701; *Annales de Chimie*, Vol. LXI. pp. 70–82; Sir Humphry Davy, "Bakerian Lectures," London, 1840, p. 51.

A.D. 1771.—In a very interesting article published by the *Gazette* at Salem (Mass.), August 9, 1889, on the occasion of the

formal opening of the new station of the Electric Lighting Company, the connection of that city with the progress of electricity was traced in the following manner :

"In 1771 Col. David Mason, a prominent figure among the patriots at Leslie's Retreat, gave a course of lectures on 'Electricity' at his house near North Bridge. The Rev. John Prince, LL.D., minister of the First Church from 1779 to 1836, was especially interested in electricity, and is said to have made the first electrical machine in Salem, if not in the country. Col. Francis Peabody, assisted by Jonathan Webb, the apothecary, was much interested in the subject, and, in 1829, gave a series of lectures, illustrated with a machine made by himself, which had a glass plate wheel imported from Germany at a reported cost of $1500.

"Dr. Charles Grafton Page, another native of Salem, invented the first electric motor in which solenoids were used, and as early as 1850 constructed a motor which developed over 10 h.p. The next year he made a trial trip with his electro-magnetic locomotive over the Baltimore and Washington Railroad. Prof. Moses Gerrish Farmer lived in Pearl Street between the years 1850 and 1870, and, as far back as 1859, illuminated the house with divided electric lights—*probably the first time that any house in the world was lighted by electricity.* In 1847 Prof. Farmer had constructed and exhibited in public an electro-magnetic locomotive drawing a car holding two passengers, on a track one foot and a half wide.

"Many of Prof. Alexander Graham Bell's early experiments were conducted in Salem, and the first lecture on the telephone in this country, if not in the world, was delivered by him before the Essex Institute in Lyceum Hall, February 12, 1877. The late Prof. Osbun, teacher of chemistry and physics at the Normal School in Salem, was also an electrical expert. He exhibited the first arc lights in Salem, and was the inventor of the storage battery system from which lights were exhibited."

The advertisement of March 7, 1765, previously alluded to herein at Kinnersley, A.D. 1761, is as follows :

"A COURSE OF EXPERIMENTS ON THE

newly discovered *Electrical Fire*, to be accompanied with methodical LECTURES on the Nature and Properties of that wonderful Element will be exhibited by DAVID MASON, at his House opposite Mr. *Thomas Jackson;* Distiller, near Sudbury-Street.—To consist of two Lectures, at one Pistareen each Lecture.—The first Lectures to be on Monday and Thursday, and the Second on Tuesday and Friday Evenings every week, Weather permitting.

"Of Electricity in General

"That the Electric Fire is a real Element,—That our Bodies at all Times contain enough of it to set an House on Fire,—That this Fire will live in Water,—A Representation of the seven Planets, shewing a probable Cause of their keeping their due Distances from each other, and the Sun in the Centre,—The Salute repulsed by the Ladies' Fire, or Fire darting from a Lady's Lips, so that she may defy any Person to salute her,—A Battery of Eleven Guns discharged by the Electric Spark, after it has passed through eight Feet of Water,—Several Experiments shewing that the Electric Fire and Lightning are the same, and that Points will draw off the Fire so as to prevent the Stroke,—With a number of other entertaining Experiments, too many to be inserted in an Advertisement.

"Tickets to be had either at his House above or at his Shop in Queen-Street."

Another advertisement, which appeared in the Salem *Gazette* of Tuesday, January 1, 1771, is thus worded : "To-morrow evening (if the Air be dry) will be exhibited A Course of Experiments in that instructive and entertaining branch of Natural Philosophy called Electricity; to be accompanied with Methodical Lectures on the nature and properties of the wonderful element; by David Mason, at his dwelling-house near the North-Bridge. The course to consist of two lectures, at a pistareen each lecture."

A.D. 1771.—Milly (Nicolas Christiern de Thy, Comte de) French chemist, constructs compass needles of an alloy of gold and ferruginous sand. These needles answered well their purpose, as did also the brass needle owned by Christian Huyghens (alluded to at A.D. 1706), a fact which received the confirmation of Messrs. Du Lacque, Le Chevalier d'Angos and M. Arderon, while the latter further ascertained that he could impart a feeble though distinct magnetic force to a brass bar either by striking it or by means of the "double touch."

References.—The Comte de Milly's "Mémoire sur la réduction des chaux métalliques par le feu electrique," read before the Paris Academy May 20, 1774, brought about many controversial articles, notably from Sigaud de la Fond, Felice Fontana, Jean M. Cadet, Jean Darcet, G. F. Rouelle and Le Dru le Comus; "Biog. Univ.," Vol. XXVIII. p. 312; *Journal de Physique*, Tome XIII. p. 393; *Philosophical Transactions*, Vol. L. p. 774; Duhamel, "Hist. Acad. Reg. Paris," p. 184; *Journal des Sçavans*, Paris edition of December 1772, and Amsterdam edition of January 1773.

A.D. 1772.—Mesmer (Friedrich Anton), an Austrian physician, who, upon taking his diploma at Vienna in 1766, had published a

thesis "On the Influence of the Planets upon the Human Body," begins his investigations as to the power of the magnet with the steel plates of Father Hell. The results proved so favourable that Hell was induced to publish an account of them, but he incurred the displeasure of his friend by attributing the cures merely to the *form* of the plates.

Mesmer subsequently arrived at the conclusion that the magnet was incapable, by itself, of so acting upon the nerves as to produce the results obtained and that another principle was necessarily involved; he did not, however, give an explanation of it, and managed to keep his process a secret for quite a while. He had observed that nearly all substances can be magnetized by the touch, and in due time he announced his abandonment of the use of the magnet and of electricity in his production of what became known as *mesmerism.*

In 1779 he published his "Mémoire sur la découverte du magnétisme animal," in which he says: "I had maintained that the heavenly spheres possessed a direct power on all of the constituent principles of animated bodies, particularly on the *nervous system,* by the agency of an all-penetrating fluid. I determined this action by the intension and the remission of the properties of matter and organized bodies, such as gravity, cohesion, elasticity, irritability and electricity. I supported this doctrine by various examples of periodical revolutions; and I named that property of the animal matter which renders it susceptible to the action of celestial and earthly bodies, *animal magnetism.* A further consideration of the subject led me to the conviction that there does exist in nature a universal principle, which, independently of ourselves, performs all that we vaguely attribute to nature or to art."

The whole theory and practice of mesmerism was, however, openly rejected by one of Mesmer's most capable pupils, Claude Louis Berthollet (A.D. 1803), a very distinguished French chemical philosopher, founder of the "Société Chimique d'Arcueil," and who, in conjunction with Lavoisier (A.D. 1781), Guyton de Morveau (A.D. 1771), and Fourcroy (A.D. 1801), planned the new philosophical nomenclature which has since proved of such service to chemical science ("La Grande Encycl.," Tome VI. p. 449; "Biog. Universelle," Tome IV. pp. 141–149).

Mesmer gave all his manuscripts to Dr. Wolfart, of Berlin, who published in 1814, "Mesmerism . . . as the general curative of mankind." And it was one of Mesmer's students, le Marquis de Puységur, who discovered magnetic somnambulism, an entirely new phenomenon in animal magnetism. (See the article "Somnambulism" in the "Encyl. Britannica," as well as the numerous works

therein quoted, relating to the above-named subjects, notably Mesmer's own "Précis historique des faits relatifs au magnétisme animal, jusques en Avril 1781.")

References.—"Bulletin de l'Acad. de Méd.," Paris, 1837, Tome I. p. 343, etc., and Tome II. p. 370; Blavatsky, "Isis Unveiled," Vol. I. p. 172, etc.; "L'Académie des Sciences," par Ernest Maindron, Paris, 1888, pp. 57–63; Richard Harte, "Hypnotism and the Doctors," Vols. I and II, New York, 1903 (from Mesmer to De Puységur, Dupotet, Deleuze, Charcot, etc.); Robert Blakey, "History of the Philosophy of Mind," London, 1850, Vol. IV. pp. 570–582, 639–645; the report of Dr. Franklin and other Commissioners . . . against mesmerism, translated by Dr. William Bache, London, 1785; J. C. Schäffer, "Abhandlung," etc., and "Kräfte," etc. (1776), "Fernere," etc. (1777), also "Journal Encyclopédique" for March 1777; Van Swinden, "Recueil," etc., La Haye, 1784, Vol. II. pp. 373–446; C. H. Wilkinson, "Elements of Galvanism," etc., Chapter XVIII; Champignon, "Etudes Physiques," etc., Paris, 1843; "Archives du Magn. Animal," published by M. Le Baron d'Hénin de Cuvillers, Paris, 1820–1823; "Report on Animal Magnetism" made by Charles Poyen Saint Sauveur, 1836; Dupotet's "Manuel," etc., Paris, 1868; Hale's "Franklin in France," 1888, Part II. chap. v. alluding to an interesting manuscript of T. Auguste Thouret now in the collection of the American Philosophical Society.

A.D. 1772.—Henley (William T.), F.R.S., invents the *quadrant electrometer*, an apparatus with which the quantity of electricity accumulated in a jar or battery can be measured through the amount of repulsion produced by the fluid upon a pith ball suspended from the centre of a graduated arc. It is generally attached to the prime conductor to measure the state of action of the electrical machine.

He is also the inventor of the *universal discharger*, for directing the charge of jars or batteries (Edw. Whitaker Gray—1748–1807—"Observations on manner glass is charged and discharged by the electric fluid" in Hutton's abridgments, Vol. XVI. p. 407).

In the *Philosophical Transactions* for 1774, Henley and Nairne give an account of many curious experiments proving the superiority of points over balls as conductors. The same is shown by William Swift in the *Phil. Trans.*, Vol. LXVIII. p. 155. (For Wm. Swift consult, besides, the *Phil. Trans.*, Vol. LXIX. p. 454, and Hutton's abridgments, Vol. XIV. pp. 314, 571.) Henley also states that the vapour of water is a conductor of electricity; that when the flame of a candle is introduced into the circuit and a Leyden jar is discharged through it, the flame always inclines toward the negative side; and he proves that electricity cannot effect a passage through glass (*Phil. Trans.*, Vol. LXVIII. p. 1049). He likewise makes a number of experiments to determine the relative conducting power of the different metals according to the quantity of a wire, each of a given size, melted by equal electrical shocks passed through them, and finds the metals to hold the order following as conductors:

gold, brass, copper silvered, silver, iron. It was also shown by Nairne that copper conducts better than iron, in the *Phil. Trans.* for 1780, Vol. LXX. p. 334.

REFERENCES.—Harris, "Rud. Electricity," 1853, p. 93, and his "Frictional Electricity," 1867, p. 23; "The Electrical Researches of the Hon. Hy. Cavendish," Cambridge, 1879, Nos. 559, 568, 569, 580; Thos. Young, "Nat. Phil." *passim*; *Phil. Trans.*, Vol. LXIV. pp. 133, 389; Vol. LXVI. p. 513; Vol. LXVII. pp. 1, 85; also Hutton's abridgments, Vol. XIII. pp. 323 (new electrometer), 512, 551, 659; Vol. XIV. pp. 90, 97, 130, 473; *Transactions of the Humane Society*, Vol. I. p. 63; Ronayne and Henley, "Account of Some Observations . . ." London, 1772 (*Phil. Trans.*, p. 137).

A.D. 1772.—Cavendish (Henry), F.R.S., eldest son of Lord Charles Cavendish, and a prominent English scientist, sometime called "The Newton of Chemistry" ("the most severe and cautious of all philosophers"—Farrar, 284), commences investigating the phenomena of electricity, the results of which study were duly communicated to the *Philosophical Transactions*. His papers embrace twenty-seven mathematical propositions upon the action of the electric fluid, and contain the first distinct statement of the difference between common and animal electricity.

Cavendish made many very important experiments upon the relative conducting power of different substances. He found that a solution of one part of salt in one part of water conducts a hundred times better, and that a saturated solution of sea-salt conducts seven hundred and twenty times better than fresh water, also that electricity experiences as much resistance in passing through a column of water one inch long as it does in passing through an iron wire of the same diameter four hundred million inches long, whence he concludes that rain or distilled water conducts four hundred million times less than iron wire.

He decomposed atmospheric air by means of the electric spark, and he successfully demonstrated the formation of nitric acid by exploding a combination of seven measures of oxygen with three of nitrogen. The latter he did on the 6th of December, 1787, with the assistance of Mr. George Gilpin, in presence of the English Royal Society. (For George Gilpin, consult "Bibl. Britan.," Vol. XXXVI, 1807, p. 3; *Phil. Trans.* for 1806.)

He improved upon Priestley's experiments after studying thoroughly the power of electricity as a chemical agent. In one of his experiments he fired as many as five hundred thousand measures of hydrogen with about two and a half times that quantity of atmospheric air, and having by this means obtained 135 grains of pure water, he was led to the conclusion which Mr. Watt had previously

maintained, that water is composed of two gases, viz. oxygen and hydrogen.

He explains why no spark is given by the electrical fishes : the latter may contain sufficient electricity to give a shock without being able to make it traverse the space of air necessary for the production of a spark, as the distance through which the spark flies is inversely (or rather in a greater proportion) as the square root of the number of jars in operation.

For an account of his experiments anticipating Faraday's discovery of the specific inductive capacity of various substances, see Chap. XI. pp. 69–142 of Gordon's "Physical Treatise," etc., London, 1883. See, likewise, J. Clerk Maxwell's "Electrical Researches," etc., Cambridge, 1879, pp. liii–lvi, as well as references therein made, more particularly at articles Nos. 355–366, 376; also the notes 27, 29 as per Index at pp. 450 and 453; *Phil. Trans.*, Vol. CLXVII (1877), p. 599; Sparks' edition of Franklin's "Works," Vol. V. p. 201.

> REFERENCES.—Dr. G. Wilson's "Life and Works of Hon. Henry Cavendish," London, 1851; Sturgeon's *Annals*, Vol. VI. pp. 137, 173, etc.; Noad, "Manual," etc., pp. 14, 161; Harris, "Electricity," pp. 136, 140; Harris, "Frictional Electricity," pp. 23 and 45; Whewell, "Hist. of the Ind. Sciences," 1859, Vol. II. pp. 203–206, 273–275, 278; C. R. Weld, "Hist. Roy. Soc.," for Lord Charles Cavendish, Vol. II. pp. 171, 176–185, 221; T. E. Thorpe, "Essays in Historical Chemistry," London, 1894, pp. 70, 110; Thomas Thomson, "Hist. Roy. Soc.," London, 1812, pp. 456, 457, 471; Sir William Thomson's "Works," 1872, pp. 34, 235; *Phil. Trans.* for 1776, Vol. LXVI. p. 196; Thos. Young, "Lectures," 1807, Vol. I. pp. 658, 664, 751, and Vol. II. p. 418.

A.D. 1773.—Walsh (John), F.R.S., demonstrates the correctness of Dr. Bancroft's opinion that the shock of the *torpedo* is of an electrical nature, resembling the discharge from a Leyden jar. In the letter announcing the fact, which he addressed to Franklin, then in London, he says : "He, who predicted and showed that electricity wings the formidable bolt of the atmosphere, will hear with attention that in the deep it speeds a humbler bolt, silent and invisible; he, who analyzed the electric phial, will hear with pleasure that its laws prevail in *animated* phials; he, who by reason became an electrician, will hear with reverence of an instructive electrician gifted at its birth with a wonderful apparatus, and with skill to use it."

Mr. Walsh's experiments were made off Leghorn, in company with Dr. Drummond, as stated in *Phil. Trans.*, 1775, p. 1, and were confirmed by Johan Ingen-housz as well as by the Italian naturalist, Lazaro Spallanzani (at A.D. 1780). The last named found the *torpedo* shocks strongest when it lay upon glass, and that when the animal was dying the shocks were not given at intervals, but resembled a

continual battery of small shocks: three hundred and sixteen of them have been felt in seven minutes.

REFERENCES.—Leithead, "Electricity," p. 135; Gray, "Elements of Natural Philosophy," 1850, p. 323; "Electrical Researches of Lord Cavendish," 1879, pp. xxxv, xxxvi and 395–437; Fifth Dissertation of "Encycl. Britannica," 8th ed. p. 738; *Phil. Trans.* for 1773, 1774, 1775 and 1776; also Hutton's abridgments, Vol. XIII. p. 469; "Chambers' Ency.," 1868, Vol. III. p. 821; "People's Cyclopædia," 1883, Vol. I. p. 628; Kaempfer (A.D. 1702); *Sc. American Supplement*, No. 457, pp. 7300, 7301; "Lettera dell' Abate Spallanzani al Signore Marchese Lucchesini," Feb. 23, 1783, inserted in the *Gothaische Gelehrte Zeitungen* for 1783, p. 409. See also the experiments of Dr. Ingram, of Kaempfer and of Borelli, described in Van Swinden's "Recueil," etc., La Haye, 1784, Vol. II; Wilkinson's "Galvanism," 1804, Vol. I. pp. 318, 324; G. W. Schilling, "Diatribe de morbo," etc., 1770, and Friedrich von Hahn in the preface to Schilling's "De Lepra," etc., 1778, as well as at pp. 436–442, Vol. I and at note, p. 160, Vol. II of Van Swinden's "Recueil," already noted; J. B. Leroy and M. Saignette "Sur. l'élect. de la Torpille," etc. (*Jour. de Phys.*, 1774, Vol. IV and for 1776, Vol. VIII); "Annales du Musée d'Hist. Nat.," p. 392; R. A. F. De Réaumur, "Mém. de l'acad. des Sc. de Paris" for 1714; C. Alibert, "Eloges," etc., Paris, 1806.

A.D. 1773.—Odier (Louis), a well-known Swiss physician, thus addresses a lady upon the subject of an electric telegraph: "I shall amuse you, perhaps, in telling you that I have in my head certain experiments, by which to enter into conversation with the Emperor of Mogol or of China, the English, the French, or any other people of Europe, in a way that, without inconveniencing yourself, you may intercommunicate all that you wish, at a distance of four or five thousand leagues in less than half an hour! Will that suffice you for glory? There is nothing more real. Whatever be the course of those experiments, they must necessarily lead to some grand discovery; but I have not the courage to undertake them this winter. What gave me the idea was a word which I heard spoken casually the other day, at Sir John Pringle's table, where I had the pleasure of dining with Franklin, Priestley and other great geniuses."

REFERENCES.—Necrology of Prof. Odier in "Bibl. Britan.," Vol. IV. N. S., 1817, pp. 317–328; see also allusion to Odier at Schwenter (A.D. 1600), and in the report of Bristol meeting of the British Association, August 25, 1875; also Chambers' "Papers for the People," 1851, *El. Com.*, p. 6; Bertholon, "Elec. du Corps Humain," 1786, Vol. I. p. 357.

A.D. 1773.—Hunter (John), a native of Scotland, "by common consent of all his successors, the greatest man that ever practiced surgery," gives at p. 481 of the *Phil. Trans.* for 1773 his observations on the anatomical structure of the *raia torpedo*.

The electricity of the animal, he found, is generated by organs on each side of the cranium and gills, somewhat resembling a galvanic pile, and consisting wholly of perpendicular columns reaching from

the upper to the under surface of the body. Dr. Walsh gave him for examination a fish about eight inches long, two inches thick and twelve inches broad, and Hunter found in each electrical organ as many as 470 columns; but in a very large fish, four and a half feet long and weighing 73 pounds, he counted as many as 1182 in each organ.

He remarks that there is no part of any animal with which he is acquainted, however strong and constant its natural action, which has so great a proportion of nerves; and he concludes that, if it be probable these nerves are not necessary for the purposes of sensation or action, they are subservient to the formation, collection or management of the electric fluid.

References.—*Phil. Trans.* for 1773, p. 461; for 1775, p. 465 (*gymnotus electricus*); for 1776, p. 196; the *Phil. Trans.*, Vol. LXIII. p. 481, (torpedo); Vol. LXV. p. 395 (gymnotus); and Hutton's abridgments, Vol. XIII. pp. 478, 666; also John Davy's account in *Phil. Trans.* for 1832, p. 259; " Am. Trans.," Vol. II. p. 166; *Nicholson's Journal*, Vol. I. p. 355; *Journal de Physique*, Vol. XLIX. p. 69; Becquerel et Brachet, *Comptes Rendus*, III. p. 135; Carlo Matteucci, " Recherches," Genève, 1837; Delle Chiage, on the organs of the torpedo; Geo. Adams, " Essay on Electricity," etc., 1785, p. 315; D. J. N. Lud. Roger, " Specimen Physiologicum," etc., Göttingæ, 1760; Dr. Buniva's experiments recorded in " Journal de Littér. Médicale," Tome II. p. 112; Leithead, " Electricity," Chap. XII; *Scient. Am. Suppl.*, No. 457, pp. 7300–7302. See also the account of his having been the first to observe the galvanic sensation of light in the experiment on the eyes, published in " Opuscoli Scelti," Vol. XXII. p. 364.

A.D. 1774.—At p. 16 of the third volume of Dr. Wm. Hooper's " Rational Recreations," etc., there is given a fine illustration of the electrical machine made by Dr. Priestley, and mention is made of the fact that, since the publication of the latter's " History and Present State of Electricity," he contrived, to be placed on the top of his house, a windmill by which the machine could be occasionally turned.

Much of the remainder of the volume is given to all kinds of experiments in the line of electricity and magnetism.

A.D. 1774.—Lesage (Georges Louis, Jr.), a Frenchman living at Geneva, Switzerland, makes in that city the first real attempt to avail of frictional electricity for the transmission of signals between two distant points (see C. M., or Charles Morrison, at A.D. 1753). His apparatus consists of twenty-four metallic wires insulated from each other and communicating with separate electrometers formed of small balls of elder held by threads and each marked with different letters of the alphabet. Whenever the electric current was transmitted, the balls indicated the desired letter.

Lesage was not, however, satisfied with a telegraph upon so

small a scale as to be utilized only in one building, and on the 22nd of June 1782 he addressed a letter to M. Pierre Prévost, at Geneva, on the subject of "a ready and swift method of correspondence between two distant places by means of electricity." This, he says, had occurred to him thirty or thirty-five years before, and had been "then reduced to a simple system, far more practicable than the form with which the new inventor has endowed it." He employed a subterranean tube of glazed earthenware, divided at every fathom's length by partitions with twenty-four separate openings intended to hold apart that number of wires, the extremities of the wires being "arranged horizontally, like the keys of a harpsichord, each wire having suspended above it a letter of the alphabet, while immediately underneath, upon a table, are pieces of gold leaf, or other bodies that can be as easily attracted, and are at the same time easily visible." Upon touching the end of any wire with an excited glass tube, its other extremity would cause the little gold leaf to play under a certain letter, which would form part of the intended message.

Georges Louis Lesage (sen.) wrote a work on "Meteors," etc., published at Geneva in 1730, and alluded to in *Poggendorff*, Vol. I. p. 1433.

References.—Abbé Moigno, "Traité," etc., 2nd ed. Part II. chap. i. p. 59; Ed. Highton, "The Electric Telegraph," 1852, p. 38; *Journal des Sçavans*, September 1782, p. 637; Pierre Prévost, "Notice," etc., 1805, pp. 176–177.

A.D. 1774.—Wales (William), English mathematician and the astronomer of Captain Cook during the expeditions of 1772, 1773 and 1774, is the first to make scientific observations relative to the local attraction of a ship upon mariners' compasses. While on his way from England to the Cape and during his passage through the English Channel he found differences of as much as 19 degrees to 25 degrees in the azimuth compass.

References.—Sturmy, at A.D. 1684; also Wales and Bayly's "Observations on Cook's Voyages," p. 49.

A.D. 1775.—Gallitzin (Dmitri Alexewitsch Fürst, Prince de), an able Russian diplomat and scientist, carries on at the Hague, between the 4th of June, 1775, and the commencement of the year 1778, a series of experiments upon atmospherical electricity, the results of which he communicates to the St. Petersburg Academy of Sciences in a Memoir entitled "Observations sur l'Electricité naturelle par le moyen d'un cerf-volant." Therein he states that the presence of electricity was always noticeable whenever he raised his kite, whether in the night or in the daytime, as well as during

hot, dry, or damp weather, and he ascertained that electricity is generally positive during calm weather and more frequently negative when the weather is stormy.

He also observed during an extensive course of experiments upon animals that hens' eggs hatch sooner when they are electrified, thus confirming the previous observations of Koeslin and Senebier, and he gives an account of the effects of battery shocks upon various species. He cites the case of a hen which had sustained the shock of sixty-four jars and appeared dead, but which revived and lived thirty-two days; and he gives the report of the dissection made by M. Munichs, as well as the very curious observations upon it noted at the time by M. Camper.

REFERENCE.—Bertholon, "Elec. du Corps Humain," 1786, Vol. I. pp. 13–14, 66, and Vol. II. p. 48, etc.; "Anc. Mém. de l'acad. Belge," Vol. III. p. 3, showing preference for the pointed form of electrical conductors; "Mercure de France," 1774, p. 147; "Biog. Univ.," Tome XV. p. 425; "Mém. de l'Acad. . . . de Bruxelles," Vol. III. p. 14; *Journal de Physique*, Vols. XXI and XXII for 1782 and 1783; "Opuscoli Scelti," Vol. II. p. 305.

A.D. 1775.—Lorimer (Dr. John), "a gentleman of great knowledge on magnetics" (1732–1795), describes his combined dipping and variation needle for determining the dip at sea, which he calls *universal magnetic needle or observation compass* in a letter to Sir John Pringle, Bart., copied in *Philosophical Transactions*, Vol. LXV. p. 79. This apparatus is also to be found described in Lorimer's "Essay on Magnetism," etc., 1795, as well as at p. 168 of Cavallo's "Treatise on Magnetism" published in 1787; and, at p. 333 of the latter work, the Doctor endeavours to explain the causes of the variation of the magnetic needle.

REFERENCES.—For Lorimer, consult Hutton's abridgments, Vol. XIII. p. 593, and, for dipping needles, refer to the same volume of Hutton, p. 613, wherein especial mention is made of those of Thomas Hutchins. The dipping needle of Robert Were Fox is described in the "Annals of Electricity," as well as at p. 411, Vol. II. of "Abstract of Papers of Roy. Soc.," and the two dipping needles of Edward Nairne are described in *Phil. Trans.* for 1772, p. 496. Capt. Henry Foster made a report on changes of magnetic intensity . . . in dipping and horizontal needles, to be found in *Phil. Trans.* for 1828, p. 303 ("Abstracts Sc. Papers . . . Roy. Soc.," Vol. II. pp. 290–296, 344).

A.D. 1775.—Cavallo (Tiberius), a distinguished Italian natural philosopher, publishes in London "Extraordinary Electricity of the Atmosphere at Islington," which volume was reprinted by Sturgeon, and contains his many experiments and important observations upon the line indicated by Franklin. This work was followed in 1777, 1782, 1787, 1795, 1802 by his "Complete Treatise on Electricity," etc.; by his "Essay on the Theory and Practice

of Medical Electricity" (London, 1780, 1781; Leipzig, 1782, 1785; Naples, 1784); and during 1787 was also published in London the first edition of his "Treatise on Magnetism," a supplement to which appeared eight years later.

He had made many very remarkable observations during the year 1787 on the phenomena of electricity in glass tubes containing mercury, and he had particularly experimented with various substances floating upon mercury in order to test their magnetism.

Before the year 1795 he contrived what he called a *multiplier of electricity*, a good illustration of which is to be found, more particularly, opposite p. 270, Vol. II. of his "Elements," etc., published at Philadelphia in 1825. It consisted of two brass plates insulated upon glass pillars, and of a third plate which could be insulated or uninsulated at will, and which, turning on a pivot, or rather a movable arm, could be made to successively convey electricity from one plate to the other until the desired quantity was accumulated. (For the *multiplier*, see Jean Damel Colladon in "Bibl. Britan.," Vol. XXIX, N.S. for 1825, p. 316.)

Cavallo also invented a small electroscope and a *condenser of electricity*. The latter consisted of an insulated tin plate between the sides of a wooden frame lined with gilt paper, one edge of the plate being connected with the body containing the electricity, and the condensation making itself observable at the opposite edge by the electroscope.

In the fourth edition of his "Treatise on Electricity" (1795), which, like the previous editions, was freely translated into other languages, will be found at pp. 285–296 of the third volume mention of the possibility of transmitting intelligence by combinations of sparks and pauses. For his experiments he made use of brass wires 250 English feet in length, and his electric alarm was based upon either the explosion of a mixture of hydrogen and of oxygen, or of gunpowder, phosphorus, phosphuretted hydrogen, etc., fired by the Leyden phial (vide Bozolus at A.D. 1767). It is in Vol. I. p. 358 of the aforenamed fourth edition that Cavallo explains the mode of action of the charged Leyden jar. His concluding words deserve reproduction: "Which shows that one side of a charged electric may contain a greater quantity of electricity than that which is sufficient to balance the contrary electricity of the opposite side. This redundant electricity should be carefully considered in performing experiments of a delicate nature." The same is expressed in other words in the 1825 American edition of his "Natural Philosophy," Chap. IV. Therein he asserts that glass is impervious to the electric fluid, saying: "If the additional electric fluid penetrates a certain way into the substance of the glass, it follows that

a plate may be given so thin as to be permeable to the electric fluid, and, of course, incapable of a charge; yet glass balls blown exceedingly thin, viz. about the six-hundredth part of an inch thick, when coated, etc., were found capable of holding a charge." (Consult Cavendish's experiments which produced this remarkable discovery, in *Phil. Trans.*, Vols. LXXV and LXXVIII.)

An electrical machine used by Cavallo in 1777 had a glass cylinder rotated by means of a cord passing around the neck and the wheel, also a cushion (amalgamated with two parts of mercury, one of tinfoil, some powdered chalk and grease) holding a silk flap and freely moving along a groove, and provided with a prime conductor resting on glass legs and with collecting points.

References.—Sturgeon, "Lectures," London, 1842, p. 12; Young's "Lectures," London, 1807, Vol. I. pp. 682, 686, 694, 714; *Nicholson's Journal*, 1797, Vol. I. p. 394; Du Moncel, "Exposé," Vol. III; Aikin's "General Biography," Vol. X; *Phil. Transactions*, 1776, Vol. LXVI. p. 407; 1777, Vol. LXVII. pp. 48, 388; 1780, Vol. LXX. p. 15; 1786, p. 62; 1787, p. 6; 1788, pp. 1 and 255, and 1793, p. 10 (Volta's letters); likewise Hutton's abridgments, Vol. XVI. pp. 57, 170, 354, 449; Vol. XIV. pp. 60, 129, 180, 608; see also "Encycl. Britannica," art. "Magnetism," Chap. III. s. 1. for Cavallo's "Observations on the Magnetism of Metals," etc.

A.D. 1775.—Bolten (Joach. Fred.), a German physician, is the author of "Nachricht von einem mit dem Künstlichen magneten gemachten Versuchein einer Nerven-Krankheit" (Hamburg, 1775), the title of which is here given in full, as the work is not usually found recorded in publications and is considered to be of excessive rarity.

Contrary to the accepted belief of many at the time, Bolten asserts that the application of magnetic plates for the cure of nervous and other affections is not only useless, but has, in many instances, been shown to greatly increase pain. This is proven by M. Fonseca in his *Journal*, which forms part of the above-named work; by Andry and Thouret ("Obs. et Rech sur. . . . l'Aimant. . . ." No. 8, pp. 599, 661), and by J. David Reuss ("Repertorium," Vol. XII. p. 18), as well as by observations recorded in another very scarce work, translated into Dutch during 1775 by the celebrated physicist, J. R. Deimann, under the title of "Geneeskundige Proefneeming met den door Koast gemaakten Magneet, door den Heere T. C. Unzer."

References.—Magnetical cures by different processes are treated of more particularly by Goclenius R., Jr., "Tract. de Mag. Curatione . . ." Marp., 1609; J. Robertus, "Curationis Magneticæ . . ." Luxemb., 1621, Coloniæ, 1622; Charlton, "A Ternary of Paradoxes . . ." London, 1650; G. Mascuelli, "De Medicina Magnetica," Franckfort, 1613, translated by W. Maxwell (Maxvellus), 1679–1687; Tentzelius, "Medicina Diastatica . . ." 1653; A. Van Leuwenhoeck (*Phil. Trans.*, Vol. XIX

for 1695–1697, as shown below); J. N. Tetens, "Schreiben . . . Magnet-curen," Bützow and Wismar, 1775; Jacques de Harsu, "Receuil des Effets . . ." Geneva, 1783; W. Pigram, "Successful Application . . ." (*Phil. Mag.*, Vol. XXXII. p. 154); Kloerich, F. W., "Versuche . . ." ("Götting. Anzeigen," 1765), "Von dem Medicin . . ." Göttingen, 1766; M. Mouzin, "De l'emploi . . . Maladies," Paris, 1843. See likewise A.D. 450, and Hell at A.D. 1770.

For Anthony Van Leuwenhoeck, consult the *Phil. Trans.* for 1695–1697, Vol. XIX. No. 227, p. 512; Vol. XXXII. p. 72; also the abridgments of Reid and Gray, Vol. VI. p. 170, and of Eames and Martyn, Vol. VI. part. ii. pp. 277–278.

A.D. 1775.—Volta (Alessandro), an Italian natural philosopher and Professor at the University of Pavia, who had already, in 1769, addressed to Beccaria a Latin dissertation, "De Vi Attractivâ ignis electrici," etc., makes known his invention of the *electrophorus*, a sort of perpetual reservoir of electricity. This consists of two circular metallic plates having between them a round disc of resin, which is excited by being struck a number of times with either a silk kerchief or pieces of dry warm fur or flannel. During 1782 he discovered what he called an electrical condenser, wherein the disc of resin is replaced by a plate of marble or of varnished wood. With this he is reported (*Philosophical Transactions*, Vol. LXXII) to have ascertained the existence of negative electricity in the vapour of water, in the smoke of burning coals, and in the gas produced by a solution of iron in weak sulphuric acid. An account of the above named and of other discoveries, as well as of various experiments, appears in letters addressed by him to Prof. Don Bassiano Carminati, of the Pavia Medical University, April 3, 1792, and to Tiberius Cavallo, Sept. 13, and Oct. 25, 1792, as shown in the *Philosophical Transactions* of the Royal Society, which institution gave him its gold Copley medal.

Volta's crowning effort lies in the discovery of the development of electricity in metallic bodies and in the production of the justly famous pile which bears his name. The latter consisted of an equal number of zinc and copper discs separated by circular plates of cloth, paper or pasteboard soaked in salt-water or dilute acid, all being suitably connected to develop a large quantity of the electric fluid. Thus, says Dr. Dickerson in his address at Princeton College, Volta gave to the world that new manifestation of electricity called Galvanism. In that form this subtle agent is far more manageable than in the form of static electricity; and by the use of galvanic batteries a current of low tension, but of enormously greater power, can be maintained with little difficulty; whereas static electricity is like lightning, and readily leaps and escapes on the surfaces on which it is confined.

"It was Volta who removed our doubtful knowledge. Such

knowledge is the early morning light of every advancing science, and is essential to its development; but the man who is engaged in dispelling that which is deceptive in it, and revealing more clearly that which is true, is as useful in his place and as necessary to the general progress of science as he who first broke through the intellectual darkness and opened a path into knowledge before unknown" (Faraday's "Researches").

The last-mentioned discovery, though made in 1796, was first announced only on the 20th of March, 1800, in a letter written from Como to Sir Joseph Banks, by whom it was communicated to the Royal Society. It was publicly read June 26, 1800 (*Phil. Trans.* for 1800, Part II. p. 408).

At pp. 428–429 of "La Revue Scientifique," Paris, April 8, 1905, will be found a review of J. Bosscha's work entitled "La correspondance de A. Volta et de M. Van Marum," published at Leyden. Bosscha calls especial attention to letters numbered XIII and XIV, dated respectively August 30 and October 11, 1792, wherein Volta describes his construction of the apparatus which, as already stated, was not made known until March 20, 1800. M. Bosscha's work is also referred to in the "Journal des Savants" for August 1905.

Volta, at about the same period, constructed an electrical battery, which has been named *La Couronne de Tasses* (the crown of cups), and which consisted of a number of cups arranged in a circle, each cup containing a saline liquid and supporting against its edges a strip of zinc and one of silver. As the upper part of each zinc strip was connected by a wire with a strip of silver in the adjoining cup, the silver strip of the first cup and the zinc strip of the last cup formed the poles of the battery. It is said that twenty such combinations decomposed water, and that thirty gave a distinct shock.

On the 16th, 18th and 20th of November 1800 (Brumaire an. IX), Volta, who had obtained permission of the Italian Government to go to Paris with his colleague Prof. Brugnatelli, delivered lectures and experimented before the French National Institute (Sue, "Histoire du Galvanisme," Vol. II. p. 267). As a member of the latter body, Bonaparte, the First Consul, who had attended the second lecture and witnessed the electro-chemical decomposition of water, proposed that a gold medal be stuck to commemorate Volta's discovery, and that a commission be formed to repeat all of Volta's experiments upon a large scale. The commission embraced such prominent men as Laplace, Coulomb, Hallé, Monge, Fourcroy, Vauquelin, Pelletan, Charles, Brisson, Sabathier, Guyton De Morveau and Biot. Biot, the chairman of the commission, made a report December 11, 1800, which appears in Vol. V of the *Mémoires de l'Institut National de France*, as well as in the *Annales de Chimie*,

Vol. XLI. p. 3. In addition to the gold medal, Volta received from Bonaparte the sum of six thousand francs and the cross of the Legion of Honour.

To Volta has been attributed the fact of having, as early as 1777, entertained the idea of an electric telegraph, although nothing more appears to be on record in relation to the matter. Fahie quotes a letter of Sir Francis Ronalds, alluding to an autograph manuscript, dated Como, April 15, 1777, and gives its translation by César Cantu, wherein Volta states that he does not doubt the possibility of exploding his electrical pistol at Milan, through wires supported by posts, whenever he discharges a powerful Leyden jar at Como.

References.—Arago, "Eloge Historique de Volta" and "Notices Biographiques," Tome I. p. 234 ("Raccolta Pratica di Scienze," etc. for March and April 1835); London *Times* of January 26, 1860; the eulogies pronounced by Giorn. Fogliani at Como and by G. Zuccala at Bergamo, the year of Volta's death, 1827; P. Sue, "Histoire du Galvanisme," Tome II. p. 267; *Journal de Leipzig*, Tome XXXIV; *Scelta d' Opuscoli*, Vols. VIII. p. 127; IX. p. 91; X. p. 87; XII. p. 94; XIV. p. 84; XXVIII. p. 43; XXXIV. p. 65; *Opuscoli Scelti*, Vols. I. pp. 273, 289; VII. pp. 128, 145; XV. pp. 213, 425; XXI. p. 373; "Mem. dell' I. R. Istit. Reg. L. V.," Vol. I. p. 24; "Mem. dell' Istit. Nazion. Ital.," Vol. I. p. 125; "Memor. Soc. Ital.," Vols. II., pp. 662, 900; V. p. 551; "Bibl. Fisica d'Europa" for 1788; "Giornale Fis.-Med.," Vols. I. p. 66; II. pp. 122, 146, 241, 287; III. p. 35; IV. p. 192; V. p. 63; "Giornale dell' Ital. Lettera," etc., Vol. VIII. p. 249; L. V. Brugnatelli, "Annali di Chimica," etc., Vols. II. p. 161; III. p. 36; V. p. 132; XI. p. 84; XIII. p. 226; XIV. pp. 3, 40; XVI. pp. 3, 27, 42; XVIII. pp. 3, 7; XIX. p. 38; XXI. pp. 79, 100, 163; XXII. pp. 223–249 (Aless. Volta and Pietro Configliachi); Aless. Volta and Angelo Bellani, "Sulla formazione," etc., Milano, 1824; F. A. C. Gren, *Neues Journal der Physik*, Vols. III and IV for 1796 and 1797; Rozier, *Observ.*, Vols. VII, XXII and XXIII for 1776, 1873; J. B. Van Mons, *Journal de Chimie*, No. 2, pp. 129, 167; Sédillot, "Receuil Per. de la Soc. de Méd. de Paris," IX. pp. 97, 231; *Journal de Phys.*, Vols. XXIII. p. 98; XLVIII. p. 336; LI. p. 334; LXIX. p. 343; *Annales de Chimie*, Vols. XXX. p. 276; XLIV. p. 396; *Nicholson's Journal*, Vol. XV. p. 3; *Phil. Tr.* for 1778, 1782 and 1793; "Soc. Philom.," An. IX. p. 48, An. X. p. 74; "Bibl. Brit.," Vol. XIX. p. 274; *Le Correspondant* for August, 1867, p. 1059, and *Les Mondes*, December 5, 1867, p. 561; Highton, "The Elec. Tel.," 1852, pp. 13 and 28; Robertson, "Mémoires Récréatifs," 1840, Vol. I. chaps. x. and xiii.; Miller, "Hist. Philos. Illustrated," London, 1849, Vol. IV. p. 333, note; Achille Cazin, "Traité théorique et pratique des piles électriques," Paris, 1881; "Mémoires de l'Institut" (Hist.) An. XII. p. 195; Andrew Crosse, "Experiments in Voltaic Electricity," London, 1815 (*Phil. Mag.*, Vol. XLVI. p. 421, and Gilbert's "Annalen," Bd. s. 60); "Lettere sulla Meteorol.," 1783; Theod. A. Von Heller, in Gilb. "Annal.," Vols. IV and VI, 1800; and *Gren's Neues Journ.*, 1795, 1797; "L'Arc Voltaique," by M. Paul Janet, in "Revue Générale des Sciences," May 15, 1902, pp. 416–422; "L'Académie des Sciences," par Ernest Maindron, Paris, 1888, pp. 245–251; "Philosophical Magazine," Vol. IV. pp. 59, 163, 306; Vol. XIII. pp. 187–190 (*re* prize founded by Napoleon); Vol. XXI. p. 289 (electrophorus); Vol. XXVIII. p. 182 (theory of Pierre Hyacinthe Azais), and p. 297 (Paul Erman on "Voltaic Phenomena"); Thomson, "Hist. of Chemistry," Vol. II. pp. 251–252; "Dict. de Gehler," Vols. III. p. 665; VI. pp. 475, 484; Thomas Thomson, "Hist. of the Royal Soc.," London,

1812, p. 451; Young's "Lectures," Vol. I. pp. 674, 677, 678, 683; see likewise the "Theory of the Action of the Galvanic Pile," as given by Dr. Wm. Henry at s. 5 Vol. I. of his "Elements of Experimental Chemistry," London, 1823; also *Nicholson's Journal* for Henry's essay in Vol. XXXV. p. 259; M. De Luc's papers in Vol. XXXII. p. 271, and Vol. XXXVI. p. 97; Mr. Singer on the "Electric Column" in Vol. XXXVI. p. 373; Dr. Bostock's essay in Thomson's "Annals," Vol. III. p. 32; Sir H. Davy's chapter on "Electrical Attraction and Repulsion," in his "Elements of Chem. Philos.," p. 125; the first volume of Gay-Lussac and Thénard's "Recherches"; Johann Mayer, "Abhandlungen . . . Galvani, Valli, Carminati u. Volta," etc., Prague, 1793; *Lehrbuch der Meteor.*, von L. F. Kaemtz, Halle, 1832, Vol. II. pp. 398, 400, 418; M. Detienne et M. Rouland in *Jour. de Phys.*, Vol. VII. for 1776; J. N. Hallé, "Exposition Abrégée," etc. ("Bull. des Sc. de la Soc. Philom.," An. X. No. 58); C. B. Désormes' very extended observations recorded in the *An. de Ch.*, Vol. XXXVII. p. 284; Volta's letter to Prof. F. A. C. Gren in 1794, and Wilkinson, "El. of Galv.," Vol. II. pp. 314–325; J. F. Ackerman ("Salz. Mediechirurg," 1792, p. 287); Cadet (*An. de Ch.*, Vol. XXXVII. p. 68); letter written by Volta to M. Dolomieu ("Bull. de la Société Philom.," No. 55, p. 48); Friedlander's "Experiments" (*Jour. de Phys.*, Pluvoise, An. IX. p. 101); Paul Erman (*Jour. de Phys.*, Thermidor, An. IX. p. 121); Gilbert's "Annalen," VIII, X, XI, XIV); *Jour. de Phys.*, Tome LIII p. 309; *Jour. de Médecine*, Nivose, An. IX. p. 351; P. C. Abilgaard, "Tentamina Electrica"; C. H. Wilkinson, "Elements of Galvanism," etc., London, 1804, 2 vols. *passim*; A. W. Von Hauch's Memoir read before the Copenhagen Acad. of Sc. (Sue, "Hist. du Galv.," 1802, Vol. II. p. 255); Alexander Nicoläus Scherer's Journal, 31st book; "Abstracts of Papers of Roy. Soc.," Vol. I. p. 27; also Hutton's abridgments of the *Phil. Trans.* Vol. XV. p. 263; Vol. XVII. p. 285; Vol. XVIII. pp. 744, 798; *Phil. Magazine*, Vol. IV. pp. 59, 163, 306; "Bibliothèque Britannique," Genève, 1796, Vol. XV. an. viii. p. 3; Vol. XIX for 1802, pp. 270, 274, 339; Vol. XVI, N.S. for 1821, pp. 270–309; account of the immense electrophorus constructed for the Empress of Russia, in Vol. I. of "Acta Petropolitana" for 1777, pp. 154, etc. In the *Philosophical Transactions* for 1778, pp. 1027, 1049, will be found Ingen-housz's paper relating to the then recent invention of Volta's *electrophorus* and to Mr. Henley's experiments. It is said that at about this time (1778), John Jacob Mumenthaler, Swiss mechanic, constructed very effective electrophori and electric machines out of a very peculiar kind of paper. M. F. Vilette also made a paper electrophorus which is alluded to by J. A. Nollet ("Experiments, Letters," Vol. III. pp. 209, etc.). Consult, besides, Carlo Barletti, "Lettera al Volta . . ." Milano, 1776; W. L. Krafft, "Tentatem theoriæ . . ." Petropol, 1778; J. C. Schäffer, "Abbild. Beschr. d. elek. . . ." Regensberg, 1778; Georg Pickel, "Experimenta physico-medica . . ." Viceburgi, 1778–1788; J. A. Klindworth, "Kurze Beschr. . . ." Gotha, 1781–1785; (Lichtenberg's "Magazin," I. 35–45;) while for Klindworth, M. Obert and M. Minkeler, see the "Goth. Mag.," I. ii. p. 35; V. iii. pp. 96, 110; E. G. Robertson, "Sur l'électrophore résineux et papiracé," Paris, 1790; (*Journal de Physique*, Vol. XXXVII;) M. Robert on the electrophorus (Rozier, XXXVII. p. 183); S. Woods, "Essay on the phenomena . . ." London, 1805; (*Phil. Mag.*, Vol. XXI. p. 289;) M. Eynard's "Mém. sur l'electrophore," Lyon, 1804; John Phillips, "On a modification of the electrophorus," London, 1833 (*Phil. Mag.*, s. 3, Vol. II); G. Zamboni, "Sulla teoria . . ." Verona, 1844 ("Mem. Soc. Ital.," Vol. XXIII); F. A. Petrina, "Neue theorie d. elect. . . ." Prag., 1846.

A.D. 1776.—Borda (Jean Charles), French mathematician and astronomer, improves upon the work of Mallet (at A.D. 1769), and

is the first to establish accurately the knowledge of the third and most important element of terrestrial magnetism, viz. its *intensity.*

To him is exclusively due the correct determination of the difference of the intensity at different points of the earth's surface by measuring the vibrations of a vertical needle in the magnetic meridian. This he determined during his expedition to the Canary Islands, and his observations were first confirmed through additional experiments which the companion of the unfortunate La Pérouse, Paul de Lammanon, made during the years 1785–1787, and which were by him communicated from Macao to the Secretary of the French Academy.

References.—Borda's biography in the "Eng. Cycl.," and in the eighth "Britannica"; Walker, "Magnetism," p. 182; Humboldt on magnetic poles and magnetic intensity, embracing the observations of Admiral de Rossel, and "Cosmos," Vol. V 1859, pp. 58, 61–64, 87–100; also Vol. I. pp. 185–187, notes, for the history of the discovery of the law that the intensity of the force increases with the latitude; Norman (A.D. 1576).

A.D. 1777.—Lichtenberg (Georg Christoph), Professor of Experimental Philosophy at the University of Göttingen, reveals the condition of electrified surfaces by dusting them with powder.

The *figures,* which bear his name, are produced by tracing any desired lines upon a cake of resin with the knob of a Leyden jar and by dusting upon the cake a well-triturated mixture of sulphur and of red lead. These substances having been brought by friction into opposite electrical conditions, the sulphur collects upon the positive and the lead upon the negative portions of the cake: positive electricity producing an appearance resembling feathers, and negative electricity an arrangement more like stars.

References.—Harris, "Frict. Elect.," p. 89; eighth "Britannica," Vol. VIII. p. 606; E. Reitlinger, "Sibven Abh. . . ." (Wien Acad.); illustrations in *Sc. Am. Suppl.*, No. 207, p. 3297; Noad, "Manual," p. 132; Erxleben's "Physikalische Bibliotek," s. 514; L. F. F. Crell, *Chemische Annalen* for 1786; "Göttingisches Magazin," J i., S ii., pp. 216–220; Lichtenberg's "Math. u. Phys. Schriften," etc., Vol. I. p. 478. See also Dr. Young's "Lectures on Nat. Phil.," London, 1807, Vol. II. pp. 119, 419 for additional references, and p. 426 for Lichtenberg's "Table of Excitation."

A.D. 1777.—Pringle (Sir John), a man of great scientific attainments—who was physician to the Duke of Cumberland as well as to the Queen's household, became a baronet in 1766, and afterward received many distinguished honours from foreign learned bodies—resigns the Presidency of the English Royal Society, which he had held since the year 1772. In this, as will be seen at a later date, he was succeeded by Sir Joseph Banks (at A.D. 1820), who continued in the office a period of over forty-two years. The cause which

led to his resignation is best given in the following extract from his biography in the English Cyclopedia :

"During the year 1777 a dispute arose among the members of the Royal Society relative to the form which should be given to electrical conductors so as to render them most efficacious in protecting buildings from the destructive effects of lightning. Franklin had previously recommended the use of points, and the propriety of this recommendation had been acknowledged and sanctioned by the Society at large. But, after the breaking out of the American Revolution, Franklin was no longer regarded by many of the members in any other light than an enemy of England, and, as such, it appears to have been repugnant to their feelings to act otherwise than in disparagement of his scientific discoveries. Among this number was their patron George III, who, according to a story current at the time, and of the substantial truth of which there is no doubt, on its being proposed to substitute knobs instead of points, requested that Sir John Pringle would likewise advocate their introduction. The latter hinted that the laws and operations of nature could not be reversed at royal pleasure; whereupon it was intimated to him that a President of the Royal Society entertaining such an opinion ought to resign, and he resigned accordingly."

In Benjamin Franklin's letter to Dr. Ingen-housz, dated Passy, Oct. 14, 1777, occurs the following: "The King's changing his *pointed* conductors for *blunt* ones is therefore a matter of small importance to me. If I had a wish about it, it would be that he had rejected them altogether as ineffectual." It was shortly after the occurrence above alluded to that the following epigram was written by a friend of Dr. Franklin :

"While you Great George, for knowledge hunt,
And sharp conductors change for blunt,
The nation's out of joint :
Franklin a wiser course pursues,
And all your thunder useless views,
By keeping to the *point*."

Thomson informs us ("Hist. Roy. Soc." pp. 446–447) that the Board of Ordnance having consulted the Royal Society about the best mode of securing the powder magazine, at Purfleet, from the effects of lightning, the Society appointed Mr. Cavendish, Dr. Watson, Dr. Franklin, Mr. Robertson and Mr. Wilson a committee to examine the building and report upon it. These gentlemen went accordingly, and the first four recommended the erecting of pointed conductors in particular parts of the building, as a means which they thought would afford complete security. Mr. Wilson dissented from the other gentlemen, being of the opinion that the conductors ought not to be pointed but blunt, because pointed conductors solicit

and draw down the lightning which might otherwise pass by. He published a long paper on the subject, assigning a great variety of reasons for his preference (*Philosophical Transactions,* Vol. LXIII. p. 49). It was this dissent of Mr. Wilson which produced between the electricians of the Royal Society a controversy respecting the comparative merits of pointed and blunt conductors, which continued a number of years, and a variety of papers in support of which made their appearance in the *Philosophical Transactions.* The controversy, in fact, engaged almost the exclusive attention of the writers on electricity for several successive volumes of that work.

References.—William Henley, "Experiments . . . pointed and blunted rods . . ." in *Phil. Trans.* for 1774, p. 133; P. D. Viegeron, "Mémoire sur la force des pointes . . ."; Edward Nairne, "Experiments . . . advantage of elevated pointed conductors," in *Phil. Trans.* for 1778, p. 823; Lord Mahon, "Principles . . . superior advantages of high and pointed conductors," London, 1779; Hale's "Franklin in France," 1880, Part I. p. 91, and Part II. pp. 254–256, 279, for some of his other correspondence with Dr. Ingen-housz; likewise Part II., pp. ix, 273, 441–451, regarding the first publication of copies of letters written by Franklin to Sir Joseph Banks, which "for some curious reason," Mr. Hale remarks, were not publicly read and were never included in the *Philosophical Transactions,* as Franklin intended they should be. Consult also Thomas Hopkinson on "The Effects of Points," etc., in Franklin's "New Experiments," etc., London, 1754; Tilloch's *Philosophical Magazine* for 1820; Hutton's abridgments, Vol. XIII. p. 382; "Memoir of Sir J. Pringle" in Weld's "Hist. of Roy. Soc.," Vol. II. pp. 58–67, 102; Jared Sparks' edition of Franklin's "Works," and Sir John Pringle's discourse delivered at the Anniversary Meeting of the Royal Society, Nov. 30, 1774, a translation of the last named appearing at p. 15, Vol. XV of the "Scelta d' Opuscoli." J. Clerk Maxwell, "Electrical Researches of the Hon. Henry Cavendish," 1879, pp. 52–54.

A.D. 1778.—Martin (Benjamin), English artist and mathematician, who had already written an "Essay on Electricity" and a prominent supplement thereto (1746–1748), publishes an enlarged edition in three volumes of his "Philosophia Britannica," originally produced in 1759. At Vol. I. p. 47 of the last-named work, he states that his experiments indicate a magnetic force inversely as the square roots of the cubes of the distances. Noad, treating of the laws of magnetic force, says ("Electricity," p. 579) that Martin and Tobias Mayer both came to the conclusion that the true law of the magnetic force is identical with that of gravitation, and that, in the previous experiments of Hauksbee and others, proper allowance had not been made for the disturbing changes in the magnetic forces so inseparable from the nature of the experiments.

His first Lecture explains all the phenomena of electricity and magnetism, the appendix thereto detailing numerous experiments of Mr. John Canton, and giving many additional facts concerning

the manufacture of artificial magnets. From his preface the following extracts will, doubtless, prove interesting: "We are arrived at great dexterity since Sir Isaac Newton's time; for we can now almost prove the existence of this *aether* by the phenomena of electricity; and then we find it very easy to prove that electricity is nothing but this very *aether* condensed and made to shine. But I believe, when we inquire into the nature and properties of this *aether* and electricity, we shall find them so very different and dissimilar, that we cannot easily conceive how they should thus mutually prove each other. . . . I see no cause to believe that the matter of electricity is anything like the idea we ought to have of the *spiritus subtilissimus* of Sir Isaac. . . . The smell also of *electrical fire* is so very much like that of *phosphorus*, that we may be easily induced to believe a great part of the composition of both is the same."

References.—"Encycl. Britan.," 1857, Vol. XIV. p. 320; Antoine Rivoire (Rivière), "Traité sur les aimants . . . " Paris, 1752; Nicolaus von Fuss, "Observations . . . aimants . . ." Petersburg, 1778; Le Noble, "Aimants artificiels . . ." Paris, 1772, and "Rapport . . . aimants," 1783 (Mém. de Paris); Wens, "Act. Hill," Vol. II. p. 264; C. G. Sjoestén (Gilbert, *Annalen der Physik*, Vol. XVII. p. 325); Rozier, IX. p. 454.

A.D. 1778.—Toaldo (Giuseppe) Abbé, celebrated Italian physicist, who had in 1762 been made Professor at the Padua University and was the first one to introduce the lightning rod in the Venetian States, makes known the merits of the last-named invention through his "Dei conduttori per preservare gli edifizj," etc., which work embraces most of his previous treatises on metallic conductors as well as the translation of H. B. de Saussure's "Exposition abrégée," etc., Geneva, 1771, and of M. Barbier de Tinan's "Considérations sur les conducteurs en général."

The above was followed by many highly interesting memoirs containing valuable meteorological observations, notably those in continuation of the work of J. Poleni, made close up to the time of Toaldo's sudden death at Padua, Dec. 11, 1798. His complete works, covering the period 1773–1798, were published in Venice through M. Tiato, with the assistance of Vincenzo Chiminello, during the year 1802.

References.—In addition to the last-named publication (entitled "Completa Raccolta d' Opuscoli," etc.), "Mem. della Soc. Ital.," Vol. VIII. pt. i. p. 29 ("Elogio . . . da A. Fabbroni," 1799); note at Beccaria, p. 42 of Ronalds' "Catalogue"; Larousse, "Dict. Universel," Vol. XV. p. 251; "Biographie Générale," Vol. XLV. p. 450; "Biografia degli Italiani Illustri," etc., by E. A. Tipaldo, Vol. VIII; "Padua Accad. Saggi," Vol. III. p. cv; "Opusc. Scelti," Vol. VI. p. 265; Vol. VII. p. 35; "Nuovo Giornale Enciclopedico di Vicenza" for 1784; Antonio Maria Lorgna, "Lettera . . . parafulmini," 1778; G. Marzari (Vol. II. p. 73, of "Treviso Athenæum"); Fonda "Sopra la maniera . . ."

Roma, 1770; G. Marzari e G. Toaldo, "Memoria Descrizione . . ." 25 Aprile, 1786; Barbier de Tinan, "Mémoire sur la manière d'armer," etc., Strasbourg, 1780; F. Maggiotto's letter to Toaldo upon a new electrical machine; Sestier et Méhu, "De la foudre," etc., Paris, 1866.

Vincenzo Chiminello, nephew of Giuseppe Toaldo, whom he succeeded at the Padua Observatory and who continued the *Giornale Astro-meteorologico* after his uncle's death, is the author of works on the magnetic needle, on lightning conductors, etc., which are treated of in the columns of the *Mem. Soc. Ital.*, Vols. VII and IX; the *Giornale Astro-met.* for 1801, 1804, 1806, as well as in the *Saggi . . . dell' Accad. di Padova*, *Nuova Scelta d' Opuscoli*, and *Opuscoli Scelti sulle scienze e sulle arti.*

References.—Chiminello's biography, *Giorn. dell' Ital. Lettera*, etc., Serie II. tome xvii. p. 164, and in "Atti della Soc. Ital.," Modena, 1819.

A.D. 1778.—Dupuis (Charles François), eminent French writer who, at the age of twenty-four, became Professor of Rhetoric at the College of Lisieux, constructs a telegraph upon the plan suggested by Amontons (at A.D. 1704). By means of this apparatus he exchanged correspondence with his friend M. Fortin, then residing at Bagneux, until the commencement of the Revolution, when he deemed it prudent to lay it permanently aside (*Encyclopædia Britannica*, 1855, Vol. VIII. p. 263).

A.D. 1778.—Brugmans—Brugman (Anton), who was Professor of Philosophy at the University of Francker between 1755 and 1766, publishes his "Magnetismus, seu de affinitatibus magneticis." He is, besides, the author of several works upon magnetic matter and the magnetic influence, which appeared 1765–1784 and are alluded to by Poggendorff ("Biog.-Liter. Hand.," Vol. I. p. 316), as well as in the "Vaderlandsche Letter" for 1775 and 1776, and at p. 34, Vol. I of Van Swinden's "Recueil de Mémoires . . ." La Haye, 1784.

It was in this same year, 1778, that Sebald Justin Brugmans—Brugman—son of Anton Brugmans, a distinguished physician, naturalist and author who was the successor of Van Swinden at the Francker University, and became Professor of Botany at Leyden, discovered that cobalt is attracted while bismuth and antimony are repelled by the single pole of a magnet, thus laying *the foundation of the science of dia-magnetism.*

Humboldt remarks: "Brugmans, and, after him, Coulomb, who was endowed with higher mathematical powers, entered profoundly into the nature of terrestrial magnetism. Their ingenious physical experiments embraced the magnetic attraction of all matter,

the local distribution of force in a magnetic rod of a given form, and the law of its action at a distance. In order to obtain accurate results the vibrations of a horizontal needle suspended by a thread, as well as deflections by a torsion balance, were in turn employed."

REFERENCES.—" Biographie Générale," Vol. VII. p. 582; Larousse, " Dict. Univ.," Vol. II. p. 1334; " Catalogue Sc. Papers Roy. Soc.," Vol. I. p. 672; W. H. Wollaston, " Magnetism of . . . Cobalt and Nickel " (*Edin. Phil. Jour.*, Vol. X. p. 183); Kohl on pure cobalt (L. F. F. Crell's " Neusten Ent.," Vol. VII. p. 39); Tyndall, " Researches on Dia-Magnetism," London, 1870, pp. 1, 90, etc.; Appleton's Encyclopædia, 1870, Vol. IV. p. 10; Humboldt's " Cosmos," 1859, Vol. V. p. 61; Augustin Roux, " Expériences nouvelles . . ." (*Journal de Médecine*, for November 1773). Consult also, for Sebald J. Brugmans, " Biog. Générale," Vol. VII. p. 582; Bory de Saint Vincent, in the " Annales Générales de Sciences Physiques," Vol. II.

A.D. 1779.—Lord Mahon, afterward third Earl of Stanhope, an Englishman of great ingenuity and fertility in invention and a pupil of Lesage of Geneva (at A.D. 1774), publishes his " Principles of Electricity," in which he explains the effects of the *return stroke* or *lateral shock* of an electrical discharge which was first observed by Benjamin Wilson (at A.D. 1746).

He imagined that when a large cloud is charged with electricity it displaces much of that fluid from the neighbouring stratum of air, and that when the cloud is discharged the electric matter returns into that portion of the atmosphere whence it had previously been taken. According to Lord Cavendish, the theory developed in the above-named work is that " A positively electrified body surrounded by air will deposit upon all the particles of that air, which shall come successively into contact with it, a proportional part of its *superabundant* electricity. By which means, the *air* surrounding the body will also become *positively* electrified; that is to say, it will form round that positive body an electrical atmosphere, which will likewise be positive. . . . That the *Density* of all such atmospheres decreases when the distance from the charged body is increased."

Tyndall says (Notes on Lecture VII) that Lord Mahon fused metals and produced strong physiological effects by the return stroke.

In 1781, the English scientist, John Turberville Needham (1713–1781), published at Brussels his French translation of Lord Mahon's work under the title of " Principes de l'Electricité." Needham was the first of the Catholic clergy elected to a fellowship of the English Royal Society, to whose Transactions be made several contributions. His numerous works include " A letter from Paris concerning some new electrical experiments made there," London, 1746, also a volume of researches upon the investigations of Spallan-

zani. The list of his communications to the *Phil. Trans.* and to the "Mém. de l'Acad. de Bruxelles" will be found in Watt's "Bibliotheca Britannica" and in Namur's "Bibl. Acad. Belge" ("Dict. Nat. Biog.," Vol. XL. p. 157; *Phil. Trans.*, 1746, p. 247, and Hutton's abridgments, Vol. IX. p. 263).

REFERENCES.—"Electrical Researches" of Lord Cavendish, pp. xlvi–xlvii *Phil. Trans.* for 1787, Vol. LXXVII. p. 130; Dr. Thomas Young, "Course of Lectures," London, 1807, Vol. I. p. 664; Dr. Thomas Thomson, "History of the Royal Society," London, 1812, p. 449; Sturgeon, "Researches," Bury, 1850, p. 398.

A.D. 1779.—Ingen-housz (Johan), distinguished English physician and natural philosopher, native of Breda, publishes, *Phil. Trans.*, p. 661, an account of the electrical apparatus which is by many believed to have led to the invention of the plate electrical, machine, although the same claim has been made in behalf of Jesse Ramsden (at A.D. 1768). Dr. Priestley states that Ingen-housz and Ramsden invented it independently of one another. He describes a circular plate of glass nine inches in diameter turning vertically and rubbing against four cushions, each an inch and a half long and placed at the opposite ends of the vertical diameter. The conductor is a brass tube bearing two horizontal branches extending to within about half an inch of the extremity of the glass, so that each branch takes off the electricity excited by two of the cushions (Dr. Thomas Young, "Course of Lectures," Vol. II. p. 432).

The plate machine of Dr. Ingen-housz is illustrated at p. 16 of "Electricity" in the "Library of Useful Knowledge." For other plate machines see, more particularly, Dr. Young's "Course of Lectures," Vol. II. p. 431; *Phil. Trans.* 1769, p. 659; Geo. K. Winter's apparatus with ring conductor and peculiar-shaped rubbers, as well as the great machine at the Royal Polytechnic, and that of Mr. Snow Harris, illustrated and described in Vol. III. p. 787, "Eng. Ency.—Arts and Sciences," and at pp. 223, 224 of J. H. Pepper's "Cyclopædic Science," London, 1869; "Allg. deutsche Biblioth.," B. XXIV. Anh. 4, Abth., p. 549, 1760 (Poggendorff, Vol. II. p. 465), relative to the machines of Martin Planta, Ingen-housz and Ramsden; Reiser's plate machine (Lichtenberg and Voigt's "Magazin für das Neueste aus der Physik," Vol. VII. St. 3, p. 73); Ferdinando Elice, "Saggio sull' Elettricita," Genoa, 1824 (for two electricities); J. J. Metzger's machine (Elice, "Saggio," second edition, p. 55); Marchese C. Ridolfi, for a description of Novelluccis' plate electrical machine ("Bibl. Italiana," Vol. LXIII. p. 268; "Antologia di Firenze," for August 1824, p. 159); Robert Hare, "Description of an Electrical Plate Machine," London, 1823 (*Phil. Mag.*, Vol. LXII. p. 8). See, besides, the machines of Bertholon (rubber in

motion) in Lichtenberg and Voigt's "Magazin," Vol. I. p. 92 and Rozier XVI. p. 74; of Brilhac (Rozier, XV. p. 377); of Saint Julien (Rozier, XXXIII. p. 367); of Van Marum (Rozier, XXXVIII. p. 447).

Dr. Ingen-housz also constructed a small magnet, of several laminæ of magnetised steel firmly pressed together, capable of sustaining one hundred and fifty times its own weight, and he found that pastes into the composition of which the powder of the natural magnet entered were much superior to those made with the powder of iron; the natural magnet, he observed, having more coercitive force than iron.

References.—*Journal de Physique* for February 1786, and for May 1788, containing the letters of Dr. Ingen-housz, which show that the vegetation of plants is in no sensible degree either promoted or retarded by common electricity. An account is also given of his experiments in "Versuche mit Plantzen," Vienna, 1778, in the "Catalogue of the Royal Society," p. 313, in "Goth. Mag.," Vol. V. iii. 13; Rozier, XXXII. p. 321; XXXIV. p. 436; XXXV. p. 81; *Journal de Physique*, Vol. XXXV for 1789. See also, *Journal de Physique*, XLV (II), 458; Rozier, XXVIII. p. 81; M. Nuneberg, "Osservazioni . . ." Milano, 1776 ("Scelta d' Opuscoli," XVII. p. 113); Pietro Moscati, "Lettera . . ." Milano, 1781 ("Opus Scelti," IV. p. 410); H. B. de Saussure (*Journal de Physique*, Vol. XXV for 1784); G. da San Martino, "Memoria. . ." Vicenza, 1785; M. Schwenkenhardt, "Von dem Einfluss . . ." (Rozier, XXVII. p. 462; *Journal de Physique* for 1786, Vol. I); A. M. Vassalli-Eandi in the "Mem. della Soc. Agr. di Torino," Vol. I for 1786, particularly regarding the experiments of Ingen-housz and Schwenkenhardt; also in the "Giornale Sc. d' una Soc. Fil. di Torino," Vol. III; N. Rouland, "Elec. appliquée aux vegétaux" (*Journal de Physique*, 1789–1790); Ingen-housz, Rouland, Dormoy, Bertholon and Derozières (Rozier, XXXV. pp. 3, 161, 401; XXXVIII. pp. 351, 427, and in *Journal de Physique*, Vols. XXXII, XXXV, XXXVIII); M. Carmoy, on the effects of electricity upon vegetation, in Rozier, XXXIII. p. 339; *Jour. de Physique* 1788, Vol. XXXIII; M. Féburier, "Mémoire sur quelques propriétés . . ."; G. R. Treviranus, "Einfluss . . ." Kiel, 1800 (Gilbert's *Annalen*, Vol. VII for 1801 and "Nordisches Arch. f. Nat. u. Arzneiw.," 1st Band, 2tes Stück); C. G. Rafn ("Mag. Encyclopédique," No. 19, Ventose An. X. p. 370), Paris, 1802; J. P. Gasc, "Mémoire sur l'influence . . ." Paris, 1823; E. Solly, "On the influence . . ." London, 1845 ("Journ. of the Hortic. Society," Vol. I. part ii.); E. Romershausen, "Galv. El. . . . Vegetation," Marburg, 1851; M. Menon, "Influence de l'électricité sur la végétation," and his letters to R. A. F. de Réaumur. Consult likewise J. Browning's letter to H. Baker, Dec. 11, 1746 (*Phil. Trans.* for 1747, Vol. XLIV. p. 373); G. Wallerius, "Versuch . . ." Hamb. and Leipzig, 1754; ("K. Schwed. Akad. Abh.," XVI. p. 257; also "Vetensk Acad. Handl.," 1754;) L. F. Kamtz (Kaemtz), "Über d. Elek . . ." Nürnberg, 1829; (Schweigger's *Journal f. Chemie u. Physik*, Vol. LVI;) Bartolomeo Zanon, "Intorno un punto . . ." Belluno, 1840; Francesco Zantedeschi "Dell influsso . . ." Venezia, 1843; ("Mem. dell Instit. Veneto," I. p. 269;) E. F. Wartmann, "Note sur les courants . . ." Genève, 1850; ("Bibl. Univ. de Genève," for Dec. 1850;) T. Pine, "Connection between Electricity and Vegetation," London, 1840; ("Annals of Electricity," Vol. IV. p. 421.) For the effects of galvanism on plants, see Giulio in "Bibl. Ital.," Vol. I. p. 28; also E. J. Schmuck "On the Action of Galvanic Electricity on the *Mimosa Pudica*," and M. Rinklake, as well as Johann W. Ritter, "Elektrische versuche an der *Mimosa Pudica*." For an account of M. P. Poggioli's observations on the influence of the *magnetic* rays on vegetation, and the reply of F.

Orioli thereto, see Vol. I of the "Nuova collezione d' opuscoli scientifici . . ." Bologna, 1817. Dr. Thomas Young's "Course of Lectures," Vol. II. pp. 432–433; N. K. Molitor's "John Ingen-housz. Anfangsgrunde . . ." 1781; Geo. Adams, "Lectures on Nat. and Exp. Philosophy," London, 1799, Vol. I. pp. 512–515; John Senebier, "Expériences," etc., 1st and 2nd Memoirs, Genève and Paris, 1788; Becquerel in the *Comptes Rendus* for November 1850, also Tome XXXI. p. 633; M. Buff (*Phil. Mag.* N. S. Vol. VII. p. 122); Priestley's "History . . ." 1775, p. 487; Walsh at A.D. 1773; Cavallo's "Exper. Philosophy," 1803, Vol. III. p. 357; Pouillet (Poggendorff's *Annalen*, Vol. XI. p. 430); Reiss, in Poggendorff's *Annalen*, Vol. LXXIX. p. 288; G. F. Gardini, "De inflvxu . . ." s. 7, p. 10; *Philosophical Transactions* for 1775, 1778, p. 1022; 1779, p. 537; *Journal de Physique*, Vol. XVI for 1780; "Erxleben's phys. bibliothek," s. 530; papers relative to the effects of electricity upon vegetation alluded to in "Le Moniteur Scientifique," more particularly at pp. 904, 907, 1026, Vol. XX for 1878, and at p. 23, Vol. XXI for 1879.

A.D. 1780.—Spallanzani (Lazaro), celebrated Italian naturalist, to whom the French Republic vainly offered the Professorship of Natural History at the Paris *Jardin des Plantes*, and who has been already particularly alluded to in connection with John Walsh, at A.D. 1773, writes a second treatise upon the operations of Charles Bonnet, of Geneva, as regards the effects of electricity upon nerves and muscles. He is also the author of works upon electrical fishes as well as upon meteors, etc., which will be found detailed in Vol. VII of the "Biographie Médicale," as well as at Vol. XLIII. p. 246, of the "Biographie Universelle."

References.—Alibert's Eloge in Vol. III of the "Mém. de la Soc. Médicale d'Emulation"; "Catal. Roy. Soc. Sc. Papers," Vol. V. p. 767; "Opus. Scelti," Vols. VII. pp. 340, 361; VIII. p. 3; XIV. pp. 145, 296; Brugnatelli, "Ann. di chimica" for 1793 and 1795; "Mem. Soc. Ital.," Vols. II. p. 11; IV. p. 476.

A.D. 1780–1781.—Bertholon de Saint Lazare (Pierre), French physician and Professor of Natural Philosophy, and a great friend of Dr. Franklin, publishes at Paris his "Electricité du Corps Humain . . ." in which he relates more particularly his general observations upon atmospheric electricity as affecting the human body while in a healthy state and while in a diseased condition. He likewise treats of the effects of electricity upon animals, and details very interesting experiments upon the *torpedo*, which latter, he remarks, establishes the closest possible resemblance to the Leyden phial.

He is also the author of "Electricité des Végétaux" (1783), as well as of "Electricité des Météores" (1787), and of a volume entitled "Electricité des Métaux." J. C. Poggendorff says ("Biog.-Lit. Handw. . . ." Vol. II. p. 102) that J. Ferd. Meidinger (1726–1777) had previously written concerning the action of electric fire upon metals and minerals. Johann Jacob Hemmer published, at Mannheim in 1780, "Sur l'Electricité des Métaux" ("Ob. sur la

Physique," July 1780, p. 50), and A. A. De La Rive wrote in 1853 "De l'Elect. Développée . . ." ("Bibl. Univ.," Vol. LIX).

REFERENCES.—Young's "Course of Lectures," Vol. II. p. 431; Ingen-housz at A.D. 1779; *Journal de Physique*, Vol. XXXV; "Biographie Universelle," Vol. IV. p. 149; "Biographie Générale," Vol. V. p. 722; Larousse, "Dict. Univ.," Vol. II. p. 618; "La Grande Encyclopédie," Vol. VI. p. 450. See also Bertholon's "Nouvelles Preuves . . ." pp. 18–19; Arago, "Notices Scientifiques," Vol. I. pp. 338–340, 386; "Mercure de France," 1782, No. 52, p. 188; Abbé d'Everlange de Wittry, "Mém. sur l'Elec. . . . dans les végétaux et le corps humain," read June 24, 1773—"Anc. Mém. de l'Acad. Belge," Vol. I. p. 181; Vassalli-Eandi, "Esame della Elett. delle Meteore del Bertholon," Torino, 1787; account of the experiments to ascertain the effects of electricity on vegetation, made in France during the summer of 1878 by MM. Grandeau, Celi and Leclerc; and a curious publication, "Les Animaux et les Métaux deviennent ils Electriques par communication," by L. Béraud (Bérault), alluded to in Poggendorff, Vol. I. p. 146.

A.D. 1780–1783.—Prof. Samuel Williams, at Cambridge, Mass., makes the earliest known observations of the magnetic dip in the United States, and publishes them in the "Memoirs of the American Academy of Arts," Vol. I. pp. 62, 68. According to this authority, the dip in 1783 was 69° 41′. The next dip observations are those made during Long's expedition to the Rocky Mountains in 1819.

REFERENCES.—"American Journal of Science," Vol. XLIII. pp. 93, 94; "Trans. Amer. Phil. Soc.," O. S., Vol. III. p. 115.

A.D. 1780–1794.—Le Père Amyot (Amiot), learned French Jesuit, who was sent in 1751 as a missionary to Pekin, where he resided till his decease in 1794, writes, on the 26th of July 1780, and also on the 20th of October 1782 that, as a result of a great number of observations, he finds no change in the variation of the magnetic needle, *i. e.* that "the point which indicates the north declines westerly from 2 to 2½ degrees, rarely more than 4½ degrees, and never less than 2 degrees."

REFERENCES.—"Mémoires concernant l'histoire," etc., Saillant et Nyon, Vol. X. p. 142; Davis, "The Chinese," Vol. III. p. 13.

A.D. 1781.—The so-called compass plant (*Silphium lancinatum*) is first introduced from America into Europe by M. Thouin and blooms for the first time in the Botanic Gardens of Upsala, Sweden.

In the "Scientific American" of February 26, 1881, reference is made to the interesting account of this plant given by Sir J. D. Hooker in Curtis' "Botanical Magazine," as well as to the following extract from Prof. Asa Gray's report concerning it: "The first announcement of the tendency of the leaves of the compass plant to direct their edges to the north and south was made by General (then Lieutenant) Alvord, of the U.S. Army, during the year 1842, and again in 1844, in communications to the American Association

for the Advancement of Science. . . . The lines in "Evangeline" (familiar to many readers):

"Look at this delicate plant that lifts its head from the meadow,
See how its leaves all point to the north as true as the magnet;
It is the compass plant that the finger of God has suspended,
Here on its fragile stalk, to direct the traveller's journey,
Over the sealike, pathless, limitless waste of the desert——"

were inspired through a personal communication made by General Alvord to the poet Longfellow.

In this connection, the following article, headed "A Wonderful Magnetic Plant," translated from *La Nature* by the London *Court Journal*, will prove interesting: "There has been discovered in the forests of India a strange plant (*Philotacea electrica*) which possesses to a very high degree astonishing magnetic power. The hand which breaks a leaf from it receives immediately a shock equal to that which is produced by the conductor of an induction coil. At a distance of six metres a magnetic needle is affected by it, and it will be quite deranged if brought near. The energy of this singular influence varies with the hours of the day. All powerful about two o'clock in the afternoon, it is absolutely annulled during the night. At times of storm its intensity augments to striking proportions. While it rains the plant seems to succumb: it bends its head during a thunder-shower and remains without force or virtue even if one should shelter it with an umbrella. No shock is felt at that time in breaking the leaves, and the needle is unaffected by it. One never by any chance sees a bird or insect alight on this electric plant; an instinct seems to warn them that in so doing they would find sudden death. It is also important to remark that where it grows none of the magnetic metals are found, neither iron, nor cobalt, nor nickel—an undeniable proof that the electric force belongs exclusively to the plant. Light and heat, phosphorescence, magnetism, electricity, how many mysteries and botanical problems does this wondrous Indian plant conceal within its leaf and flower!"

The results of some interesting researches on plant-electricity have been reported by A. D. Waller, who finds that whenever a plant is wounded, a positive electric current is established between the wounded part and the intact parts. This may start with an electromotive force of 0·1 volt, but it afterward diminishes. He writes further:

"Actual wounding is not necessary to obtain this manifestation; an electropositive current is set up when there is mechanical excitation, but it is much weaker (0·02 volt). And light acts like mechanical excitation with certain plants, such as the leaves of the iris, of tobacco, of the begonia, etc. From the illuminated to the

darkened part flows a positive electric current that may be as strong as 0·02 volt. A similar reaction in the petals is not always observed. There is a certain correlation between the vigour of a plant and the electric reaction. The more vigorous the plant is, the stronger the current. Plants grown from fresh seeds give a more powerful current than those from old seeds. A bean a year old gave a current of 0·0170 volt; one five years old, a current of 0·0014; and the reaction is inversely and regularly proportional to the age of the seed from which the plant springs. There is observed in vegetable tissues, subjected to an excitation of the same intensity at regular intervals, the characteristic changes of reaction that are present in animal tissues—fatigue, recuperation, etc. Temperature plays a part in all these phenomena; below — 4° to — 6° C. [+ ° to + 25° F.] and above 40° C. [108° F.] there is no reaction."

A.D. 1781.—Lavoisier (Antoine Laurent), an eminent French natural philosopher, the chief founder of modern chemistry as well as of the prevailing system of chemical nomenclature which ended in the expulsion of the phlogistic theory, demonstrates by experiments made in conjunction with Volta and Laplace that electricity is developed when solid or fluid bodies pass into the gaseous state. Sir David Brewster says that the bodies to be evaporated or dissolved were placed upon an insulating stand and were made to communicate by a chain or wire with a Cavallo electrometer, or with Volta's condenser, when it was suspected that the electricity increased gradually. When sulphuric acid, diluted with three parts of water, was poured upon iron filings, inflammable air was disengaged with a brisk effervescence; and, at the end of a few minutes, the condenser was so highly charged as to yield a strong spark of negative electricity. Similar results were obtained when charcoal was burnt on a chafing dish, or when fixed air or nitrous gas was generated from powdered chalk by means of the sulphuric and nitrous acids.

The phlogistic theory alluded to above, which was so named by George Ernest Stahl in 1697 after Johann Joachim Beccher (1635–1682) had pointed out its principle in 1669, had for its most energetic defender the editor of the *Journal de Physique*, M. J. C. De La Méthérie, who is entered at A.D. 1785, and it was in order to offset the influence which this gave him that the antiphlogistians established the *Annales de Chimie*, so frequently mentioned in these pages.[1]

[1] "The first sound theory of chemistry was denominated the *anti-phlogistic*, in contradistinction to that of *phlogiston*, or the principle of inflammability, which was first proposed by Beccher (born at Spires in Germany in the year 1635) and then improved by Stahl, a native of Anspach, in honour

REFERENCES.—George Adams' "Lectures on Nat. and Exp. Philosophy," London, 1799, Vol. I. pp. 575–587, wherein Lavoisier's system is confuted by the German chemist Wieglib, whose views are endorsed by Mr. Green, while for Stahl and Beccher, refer to Sir H. Davy, "Bakerian Lectures," London, 1840, p. 102, note, to "Biog. Gén.," Vol. V. pp. 85–87; "Meyer's Konvers. Lexikon," Vol. II. p. 654, and to Thomson's "Hist. of Roy. Soc.," London, 1812, p. 467. See also J. M. G. Beseke, "Ueber elementärfeuer . . ." Leipzig, 1786; G. A. Kohlreif, "Sollte die elektricität . . ." Weimar, 1787; Lavoisier and Laplace, in the "Mém. de l'Acad. Roy. des Sciences" for 1781, p. 292; Lavoisier's "Opuscules . . ." 1774, and his "Rapport . . . mag. animal.," Paris, 1784; Dr. Thomas Thomson, "Hist. Roy. Soc.," pp. 479–486; Herschel's "Nat. Phil.," concerning the third age of chemistry; Grégoire, "Dict. d'hist.," etc., p. 1171; Miller's "Hist. Phil. Illus.," London, 1849, Vol. IV. pp. 332–333, notes. Chap. IV of the "History of Chemistry," Ernst Van Meyer, tr. by George McGowan, London, 1898, entitled "History of the Period of the Phlogiston Theory from Boyle to Lavoisier," will prove interesting. "La chimie constituée par Lavoisier," Jacob Volhard, in "Le Moniteur Scientifique," du Dr. Quesneville, Vol. XIV for 1872, pp. 50–71; "Nouveau Larousse," Vol. V. p. 608; "La Révolution chimique," M. Berthelot, Paris, 1890; "Essays in Historical Chemistry," T. E. Thorpe, London, 1894, pp. 87, 110; "Journal des Savants" for Nov. 1859 and Feb. 1890; "Lives of Men of Letters and Science," by Henry, Lord Brougham, Philadelphia, 1846, pp. 140–166.

A.D. 1781.—Achard (Franz Carl), able chemist and experimental philosopher, born in Prussia but of French extraction, communicates to the "Mém. de Berlin" a report of many very interesting experiments made by him, which are reviewed by Prince Dmitri Alexewitsch Fürst Gallitzin, in Vol. XXII of the *Journal de Physique.*

He had previously published essays upon the electricity of ice and the electricity developed on the surface of bodies, as well as upon terrestrial magnetism, the electrophorus, etc. He made many notable investigations to prove that fermentation is checked by electricity and that putrefaction is hastened both in electrified meats and in animals killed by the electric shock.

One of his experiments illustrating galvanic irritation so greatly interested Humboldt that the latter repeated it with different animals, not doubting but small birds might in many cases be brought back to life when they fall into a state somewhat resembling death. On one occasion, he took a linnet about to expire and, having established the necessary communication, perceived, the moment the contact took place, that the linnet opened its eyes, stood erect upon its feet and fluttered its wings; it breathed, he says, during six or eight minutes and then expired tranquilly.

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of whom it has been commonly denominated the Stahlian theory. The difference between the two theories is briefly this, that according to the earlier a body is conceived to be deprived in combustion of a component principle, whereas according to the later a component part of the atmosphere is conceived to be combined with it" (Dr. Geo. Miller, from Thomson's "History of Chemistry," London, 1830, Vol. I. pp. 246, 250, and Vol. II. pp. 99–100).

It was a namesake of Achard who invented the electro-magnetic brake which will be found described and illustrated in articles from the London *Engineer* and *Engineering*, reproduced through the *Scientific American Supplements*, No. 111, p. 1760, and No. 312, p. 4974.

References.—Poggendorff, "Biog.-Lit. Hand. . . ." Vol. I. p. 7; "Biographie Générale," Vol. I. p. 176; "Cat. Roy. Soc. Sc. Papers," Vol. I. p. 9; "Opus. Scelt.," Vols. III. p. 313; V. p. 351; VI. p. 199; Reuss, *Repertorium*, Vol. IV. p. 351; Dr. G. Gregory, "Economy of Nature," London, 1804, Vol. I. p. 317; Van Swinden, "Recueil . . ." La Haye, 1784, Vol. I. p. 24; "Biographie Universelle," Vol. I. p. 114; "Journal Lit. de Berlin," for 1776; Cavallo, London, 1777, p. 403; "Mém. de Berlin" for 1776–1780, 1786, 1790–1791; Sturgeon, "Lectures," London, 1842, p. 12; Geo. Adams, "Essay on Electricity," etc., London, 1785, pp. 214–220, 277; "Gött. Mag.," Vol. II. ii. 139; Rozier, VIII. p. 364; XV. p. 117; XIX. p. 417; XXII. p. 245; XXIII. p. 282; XXV. p. 429; XXVI. p. 378; *Phil. Mag.*, Vol. III. p. 51.

A.D. 1781.—Kirwan (Richard), LL.D., F.R.S., an Irish chemical philosopher of great eminence, who became President of the Dublin Society and of the Royal Irish Academy, receives from the English Royal Society its gold Copley medal for the many valuable scientific papers communicated by him to the latter body. These papers embrace his "Thoughts on Magnetism," wherein he treats at length of attraction, repulsion, polarity, etc., as shown in the review given at pp. 346–353 of the eighth volume of Sturgeon's "Annals of Electricity," etc.

It is said that Kirwan first suggested the notion of molecular magnets, but, according to Dr. J. G. M'Kendrick, it was not till a definite form was given thereto by Weber that it acquired any importance.

References.—*Transactions Royal Irish Academy*, Vol. VI; Ninth "Encycl. Britannica," Vol. XV. p. 276; *Phil Mag.*, Vol. XXXIV. p. 247; Thomson, "Hist. of the Roy. Soc.," p. 483; "Bibl. Britan.," An. VII. vol. xii. p. 105.

A.D. 1781.—Mauduyt (Antoine René) (1731–1815), Professor at the Collège de France, publishes several observations from which he concludes that the application of electricity is favourable in cases of paralysis. He was in the habit of placing the patient upon an insulated stool, in communication with the conductor of an electrical machine. De La Rive, who mentions the fact ("Electricity," Chap. III. pp. 586, 587), observes that the effect, if any, could only proceed from the escape of electricity into the air.

References.—Bertholon, *Elec. du Corps. Humain*, 1786, Vol. I. pp. 275–276, 302, 439, 447, etc., and Vol. II. pp. 7 and 296; "Mémoire sur les différentes manières d'administrer l'électricité," etc., Paris, 1784; "Recueil sur l'électricité médicale," etc., containing articles by G. F. Bianchini, De Lassoné, Deshais (*see* Sauvages), Dufay, Jallabert, Pivati,

Quellmalz, Veratti, Zetzell, etc.; K. G. Kuhn's works published at Leipzig, 1783–1797; E. Ducretet in "Le Cosmos," Paris, Oct. 3, 1891, pp. 269–272; P. Sue, aîné, "Hist. du Galvan," Paris, An. X–XIII, 1802, Vol. I. p. 40; and Vol. II. p. 382; "Grande Encyclop.," Vol. XXIII. p. 415.

A.D. 1781–1783.—Don Gauthey—Gauthier or Gualtier—a monk of the Order of Citeaux, improved upon the invention of Dupuis (at A.D. 1778) and constructed a telegraph, which he submitted at the Académie des Sciences to Dr. Franklin as well as to Condorcet and De Milly, by whom it was recommended to the French Government. In his prospectus, published during 1783, he relates that he has discovered a new mode of rapid transmission enabling him to convey intelligence and sound, by means of water pipes, a distance of fifty leagues in fifty minutes. Ternant, who states this at pp. 33 and 34 of *Le Télégraphe*, Paris, 1881, adds that, as no action was taken at the time upon the prospectus, it doubtless still lies in the archives of the Academy.

References.—Laurencin, *Le Télégraphe*, p. 9; Eng. Cycl., "Arts and Sciences," Vol. VIII. p. 65; "Penny Cycl.," 1842, Vol. IV. p. 146.

A.D. 1782.—Nairne (Edward), an English mathematical instrument maker, publishes papers on electricity describing his invention of a cylinder machine which is illustrated and described at p. 15 of the chapter on "Electricity" in "Library of Useful Knowledge," 1829. In this, as has been truly said, are seen all the essential parts of the frictional apparatus now in use.

This machine, according to Cuthbertson, was originally constructed in 1774, and was far more powerful than any before made. Nairne also constructed the largest battery known up to that time. It contained 50 square feet of coated surface, and it could be given so high a charge as to ignite 45 inches of iron wire $\frac{1}{150}$ of an inch diameter, which up to that period was the greatest length of wire ever ignited. Nairne, while improving upon some of Priestley's experiments, found that a piece of hard drawn iron wire, ten inches long and one-hundredth of an inch diameter, after receiving successively the discharge of 26 feet of coated glass (nine jars), was shortened three-fortieths of an inch by such discharge. Dr. Priestley had previously observed that a chain 28 inches long was shortened one quarter of an inch after having had transmitted through it a charge of 64 square feet of coated glass, and Brooke Taylor found that by passing a charge of nine bottles of 16 feet of coated surface nine times in succession through a steel wire 12 inches long and one one-hundredth of an inch diameter, the wire was shortened one and one-half inches, or one-eighth its entire length.

To Nairne was granted the third English patent in the Class of Electricity and Magnetism, the first having been issued to Gowin

Knight in 1766 (see A.D. 1746) and the second to Gabriel Wright, June 25, 1779, for "a new constructed azimuth and amplitude compass." Knight subsequently covered other similar inventions, July 5, 1791, and Jan. 19, 1796. Nairne's patent bears date Feb. 5, 1782, No. 1318, and is for what he calls "The Insulated Medical Electrical Machine," the conductors of which are so arranged as to readily give either shocks or sparks. He says that "by means of the conductors and jointed tubes, the human body can be in any part affected with either kind of electricity in any convenient manner."

REFERENCES.—*Philosophical Transactions* for 1772, 1774, 1778, 1780, 1783, Vol. LXIV. p. 79; Vol. LXVIII. p. 823; Vol. LXX. p. 334; also Hutton's abridgments, Vol. XIII. pp. 360 (dipping needle), 498; Vol. XIV. pp. 427–446, 688; Vol. XV. p. 388; "General Biog. Dict.," London, 1833, by John Gorton, Vol. I. (n. p.); Cuthbertson, "Practical Electricity," London, 1807, pp. 165–168; article "Electricity," in the "Encycl. Britannica"; "Description of . . . Nairne's . . . Machine," London, 1783 and 1787; Caullet de Veaumorel, "Description de la machine électrique négative et positive de Mr. Nairne," Paris, 1784; Delaunay's "Manuel," etc., Paris, 1809, pp. 7, 12–14.

A.D. 1782–1783.—Linguet (Simon, Nicolas, Henri), French advocate (1736–1794), who was an associate of Mallet du Pan in the preparation of the *Annales Politiques* and who was later on committed to the Bastille in consequence of a visit which he imprudently made to Paris, writes a letter to the French Ministry proposing a novel method of transmitting messages of any length or description by means of some kind of a telegraph, "nearly as rapidly as the imagination can conceive them." He adds, "I am persuaded that in time it will become the most useful instrument of commerce for all correspondence of that kind; just as electricity will be the most powerful agent of medicine; and as the fire-pump will be the principle of all mechanic processes which require, or are to communicate, great force."

To Linguet has been attributed the authorship of the anonymous letter which appeared in the *Journal de Paris* of May 30, 1782, and in *Le Mercure de France* of June 8, 1782, wherein it is proposed to employ twenty-four pairs of gilt wires, placed underground in separate wooden tubes filled with resin and bearing a knob at each extremity. Between each pair of knobs was to be placed a letter of the alphabet, which would become discernible whenever the electric spark was passed through the wire by means of the Leyden phial.

REFERENCES.—Ternant, *Le Télégraphe*, Paris, 1881, p. 11; Linguet, "Mém. manuscrit . . . signaux par la lumière," Paris, 1782; all about the "Mercure de France," in "Bulletin du Bibliophile" No. 7 of July 15, 1902; "Biog. Dict.," Alex Chalmers, 1815, Vol. XX. p. 290; "Nouv. Biog. Gén." (Hœfer), Paris, 1860, Vol. XXXI. p. 279; "Biog. Univ." (Michaud), Vol. XXIV. p. 565.

A.D. 1782–1791.—Cassini (Jean Jacques Dominique, Comte de), son of Cassini de Thury, eminent astronomer, makes the very important announcement that, besides the *secular* variation of the declination, the magnetic needle is subject to an *annual* periodical fluctuation depending on the position of the sun in reference to the equinoctial and solstitial points.

Cassini's discovery is contained in a Memoir consisting of two parts, the first part being a letter addressed to L'Abbé Rosier and published by him in the *Journal de Physique,* while the second part, composed at request of the Académie des Sciences, is that which specially treats of the *annual variation in declination.*

Besides the last named, we have thus far learned of the *secular* variation discovered by Gellibrand (Hellibrand) in 1635, as well as of the *diurnal* and *horary* variations, first accurately observed by George Graham during the year 1722, and we have likewise been informed of the earliest observations of *the dip or inclination,* made independently by both Georg Hartmann (A.D. 1543–1544) and by Robert Norman (A.D. 1576), as well as of the determination of the intensity of the inclination by J. C. Borda (at A.D. 1776). For accounts of the *secular* and *annual,* as well as of the *diurnal* and *horary* variations of the dip, the reader should consult the First Section of Humboldt's "Cosmos" treating of telluric phenomena and some of the very numerous references therein given.

Speaking of the influence of the sun's position upon the manifestation of the magnetic force of the earth, Humboldt remarks that the most distinct intimation of this relation was afforded by the discovery of *horary* variations, although it had been obscurely perceived by Kepler, who surmised that all the axes of the planets were magnetically directed toward one portion of the universe. He says that the sun may be a magnetic body, and that on that account the force which impels the planets may be centred in the sun (Kepler, in "Stella Martis," pp. 32–34—compare with it his treatise, "Mysterium Cosmogr.," cap. 20, p. 71). He further observes that the *horary* variations of the declination, which, although dependent upon true time are apparently governed by the sun as long as it remains above the horizon, diminish in angular value with the magnetic latitude of place. Near the equator, for instance, in the island of Rawak, they scarcely amount to three or four minutes, whilst the variations are from thirteen to fourteen minutes in the middle of Europe. As in the whole northern hemisphere the north point of the needle moves from east to west on an average from 8½ in the morning until 1½ at midday, in the southern hemisphere the same north point moves from west to east (Arago, *Annuaire,* 1836, p. 284, and 1840, pp. 330–358). Attention has been drawn,

with much justice, to the fact that there must be a region of the earth, between the terrestrial and the magnetic equator, where no horary deviations in the declination are to be observed. This fourth curve (in contradistinction to the *isodynamic, isoclinic* and *isogonic* lines, or those respectively of equal force, equal inclination and equal declination), which might be called the *curve of no motion,* or rather *the line of no variation of horary declination,* has not yet been discovered. No point has hitherto been found at which the needle does not exhibit a *horary* motion, and, since the erection of magnetic stations, the important and very unexpected fact has been evolved that there are places in the southern magnetic hemisphere at which the *horary* variations of the dipping needle alternately participate in the phenomena (types) of the hemispheres.

Humboldt also alludes, in the article on " Magnetic Variation," to his recognition of the " four motions of the needle, constituting, as it were, four periods of magnetic ebbing and flowing, analogous to the barometrical periods," which will be found recorded in Hansteen's " Magnetismus der Erde," 1819, s. 459, and he likewise refers to the long-disregarded *nocturnal* alterations of variation, for which he calls attention to Faraday " On the Night Episode," ss. 3012–3024. (See also, Poggendorff's *Annalen der Physik,* Bd. XV. s. 330, and Bd. XIX. s. 373.)

The *Phil. Trans.* for 1738, p. 395, contain the description of a new compass for ascertaining the variation " with greater ease and exactness than any ever yet contrived for that purpose." This was devised by Capt. Christopher Middleton, whose many interesting observations are to be found in the same volume of the *Phil. Trans.,* p. 310, as well as in the volumes for 1726, p. 73; 1731–1732, 1733–1734, p. 127; 1742, p. 157, and in John Martyn's abridgment, Vol. VIII. part i. p. 374. Reference should also be made to the volumes for 1754 (p. 875) and 1757 (p. 329), giving the reports of W. Mountaine and J. Dodson upon the magnetic chart and tables of 50,000 observations, likewise to the volume for 1766 containing the report of W. Mountaine on Robert Douglass' observation, as well as for the record of investigations of the variation made by David Ross on board the ship " Montagu " during the years 1760–1762.

References.—Sabine, " On the Annual and Diurnal Variations," in Vol. II of " Observations made . . . at Toronto," pp. xvii–xx, also his Memoir " On the Annual Variation of the Magnetic Needle at Different Periods of the Day," in *Phil. Trans.* for 1851, Part II. p. 635, as well as the Introduction to his " Observations . . . at Hobart Town," Vol. I. pp. xxxiv–xxxvi, and his Report to the British Association at Liverpool, 1854, p. 11—*Phil. Trans.* for 1857, Art. 1, pp. 6, 7—relative to the *lunar diurnal magnetic variation.* See likewise C. Wolf, " Histoire de l'observatoire depuis sa fondation à 1793 "; Houzeau et Lancaster,

"Bibl. Gen.," Vol. II. p. 102; "Mém. de Paris," Vol. II. p. 74, and Vol. VII. pp. 503, 530; Walker, "Ter. and Cos. Magn.," Chap. III; Mme. J. Le Breton, "Histoire et Applic.," etc., Paris, 1884, p. 17; Robison, "Mech. Phil.," Vol. IV. p. 356; Thos. Young, "Nat. Phil.," 1845, p. 583.

Cassini Family

This celebrated family, to which allusion was made under A.D. 1700, deserves here additional notice.

Giovanni Domenico Cassini (1625–1712), the first and greatest of the name, succeeded Buonaventura Cavalièri in the astronomical chair of the Bologna University in 1650, and remained there until given the directorship of the Paris Royal Observatory upon its completion in 1670. Partly with the assistance of his learned nephew, James Philip Maraldi, Cassini made many important discoveries, among which may be signalled the finding of the first, second, third and fifth satellites of Saturn, as well as the dual character of that planet's ring, the determination of the rotation of Jupiter, Mars and Venus, and the laws of the moon's axial rotation. (See Thomson, "Hist. of the Roy. Soc.," p. 331; "Anc. Mém. de Paris," I, VIII, X; Thos. Morrell, "Elem. of the Hist. of Phil. and Sc.," London, 1827, pp. 377–379.)

Jacques (James) Cassini (1677–1756), the only son of the preceding, became director of the Paris Observatory upon the death of his father, made many very important astronomical observations, and wrote several treatises upon electricity, etc. In one of his works, "De la Grandeur et de la Figure de la Terre," Paris, 1720, he gives an account of the continuation of the measurement of Picard's arc of the meridian from Paris northward, begun by Domenico Cassini and La Hire in 1680, and recommenced by Domenico and Jacques Cassini in 1700. (See "Mém. de Paris," Vol. VII. pp. 455, 456, 508, 572; and for years 1705, pp. 8, 80; 1708, pp. 173, 292; 1729, Hist. I., Mem. 321.)

Cesar François Cassini de Thury (1714–1784), son of Jacques, whom he in turn succeeded at the Observatory, was, as above stated, the father of Jean Dominique Cassini (1747–1845). He made numerous researches while in the Director's Chair, his most remarkable work being the large triangulation of France published in 1744, under the title of "La Méridienne," etc. (See "Hist. de l'Acad. des Sciences de Paris" pour 1752, p. 10.)

A.D. 1783.—Robespierre (François-Maximilien-Joseph-Isidore de), who afterward became leader of the famous French Jacobin Club, and was at the time practising law in his native town of Arras, distinguishes himself by successfully defending the cause of the Sieur de Vissery de Boisvalé, a landed proprietor of that place, who had

erected a lightning conductor on his house, " much to the scandal of the discreet citizens " of the locality—" Deistical philosophy; away with it ! " (Eighth " Britannica," Vol. XIX. p. 233).

Mr. de Boisvalé's case was an appeal from a judgment delivered by the sheriff of Saint-Omer, ordering the destruction of the lightning conductor, and its printed report bears the following epigraph :

" L'usage appuyé sur les temps
Et les préjugés indociles.
Ne se retire qu'à pas lents
Devant les vérités utiles."

Jean Paul Marat, docteur en médecine et médecin des Gardes de corps de M. le Comte d'Artois, who, like Robespierre, was a member of the French National Convention as well as a declared enemy of the Girondins, and who was killed by Charlotte Corday, July 13, 1793, made many electrical experiments. These greatly interested Benjamin Franklin, who used to visit him (Ninth " Encycl. Brit.," Vol. XV. p. 526). He was the author of many electrical works during the years 1779–1784, notably " Découvertes sur le feu, l'électricité et la lumière," " Recherches Physiques," and a memoir on medical electricity (" Œuvres de Marat," Paris, 1788; A. Bougeart, " Marat, l'ami du peuple," 1864; F. Chevremont, " Jean Paul Marat," 1881).

References.—Ronalds' " Catalogue," p. 434; *La Lumière Electrique* for Sept. 5, 1891; the *Electrician*, London, Sept. 11, 1891.

A.D. 1783.—Wilkinson (C. H.), Scotch physician, publishes at Edinburgh his " Tentamen Philosophico-medicum de Electricitate," which is followed, during 1798 and 1799, by other works upon electricity, wherein he cites a number of marvellous cures of intermittent fevers similar to those made by Cavallo, also of amaurosis (*goutte sereine*) and of quinsy (*squinancie*) like those performed by Lovet, Becket and Mauduyt.

During the year 1804 appeared the first edition, in two volumes, of his " Elements of Galvanism in Theory and Practice," containing a very comprehensive review of the discovery from the time of Galvani's early experiments. In this last-named work, however, he shows that incipient amaurosis and the completely formed gutta serena have not yielded to his own treatment by galvanic influence as had been the case with Dr. C. J. C. Grapengieser, who published many accounts of surprising cures (Grapengieser, " Versuche den Galvanismus . . ." Berlin, 1801 and 1802, or Brewer and Delaroche, " Essai . . ." Paris, 1802). The whole of Chap. XXXVI is devoted to the application of galvanism to medicine, whereto allusion had already been made in the first chapter of the same work.

Wilkinson refers also to the electricity of the *torpedo,* and to the observations made thereon by Hippocrates, Plato, Theophrastus, Pliny and Ælian, also by Belon, Rondelet, Salviana and Gesner, as well as by Musschenbroek, Redi, Réaumur, Walsh, Hunter, Spallanzani, 'Sgravesande, Steno, Borelli, Galvani and others. Much space is likewise given to the observations recorded on animal electricity, notably by Fontana, De La Méthérie, Berlinghieri, Vassali-Eandi, Humboldt, Pfaff, Lehot, Hallé, Aldini, and to the experiments of Valli as they were repeated before the French Academy of Sciences and before the Royal Society of Medicine of Paris, in presence of M. Mauduyt. When treating of the powers of galvanism as a chemical agent, reference is made to the decomposition of water, thus first effected in 1795 by Creve, the discoverer of metallic irritation, and to the operations of Nicholson and Carlisle, Dr. Henry, Cruikshanks, Haldane, Henry Moyes, Richter, Gibbes, etc.

References.—J. J. Hemmer, "Commentat Palatinæ," VI, Phys., p. 47; Bertholon, "Elec. du Corps Humain," 1786, Vol. I. pp. 314, 330, 483, and Vol. II. p. 299; "Bibl. Britan.," 1808, Vol. XXXVIII. p. 270 (*Phil. Mag.*, No. 105); *Annales de Chimie,* Vol. LXXVIII. p. 247; *Phil. Mag.,* Vol. XXIX. p. 243, and Vol. XLIX. p. 299; F. Buzzi, "Osservazione . . . amaurosi . . . elettricita," Milano, 1783 ("Opus. Scelti," Vol. VI. p. 359); *Nicholson's Journal,* Vol. VIII. pp. 1, 70, 206; also Vol. X. pp. 30–32, for letter relative to certain erroneous observations of Mr. Wilkinson respecting galvanism, by Mr. Ra. Thicknesse, who also wrote in Vol. IX. pp. 120–122, explaining the production of the electric fluid by the galvanic pile.

A.D. 1783.—Saussure (Horace-Benedict de), Professor of Physics at the University of Geneva and founder of the Society for the Advancement of the Arts in the same city, is the inventor of an electrometer designed to ascertain the electrical state of the atmosphere, which will be found described in Vol. VIII. p. 619 of the 1855 "Encycl. Britannica."

He observed that electricity is strongest in the open-air, that it is weak in streets, under trees, etc., and that during the summer and winter, by night as well as by day, when the atmosphere is free from clouds, the electricity of the air is always positive. In contradistinction, Mr. T. Ronayne found in Ireland that the electricity of the atmosphere is positive in winter when the air is clear, but that it diminishes in frosty or foggy weather and that he could detect no electricity in the air during summer except on the approach of fogs, when the electricity proved to be positive. During the year 1785, M. de Saussure observed at Geneva that, during the winter, the intensity of atmospherical electricity attained its first maximum at 9 a.m., diminishing from that hour until it reached its minimum at 6 p.m., after which it began to increase until attaining its second maximum at 8 p.m., diminishing gradually thereafter till

it recorded its second minimum at 6 a.m. During the summer he found the electricity increasing from sunrise till between 3 and 4 p.m., when it would reach its maximum; after that it appeared to diminish till the dew fell, when it again became stronger, but was scarcely sensible during the night.

Sir David Brewster informs us in his able article on "Electricity" in the "Britannica" that De Saussure made a number of elaborate experiments on the electricity of evaporation and combustion. He observed at first that the electricity was sometimes positive and sometimes negative when water was evaporated from a heated crucible, but in his subsequent trials he found it to be always positive in an iron and in a copper crucible. In a silver, also in a porcelain crucible, the electricity was negative and the evaporation of both alcohol and of ether in a silver crucible also gave negative electricity. M. de Saussure made many fruitless attempts to obtain electricity from combustion, and he likewise failed in his efforts to procure it from evaporation without ebullition.

To De Saussure is often erroneously attributed the authorship of Lullin's "Dissertatio physica de electricitate," alluded to at A.D. 1766.

REFERENCES.—De Saussure's "Dissertatio de Igne," "Exposition abrégée," etc. (translated by Giuseppe Toaldo, in both his "Della maniera," etc., and "Dei conduttori," etc., Venezia, 1772 and 1778), "Voyage dans les Alpes," all published at Geneva, 1759, 1771, 1779, also the important 1786 Neuchatel edition of the last-named work, more particularly at pp. 194, 197, 203, 205, 206, 211, 212, 216, 218, 219, 228, 252, 254 of Vol. II, and at pp. 197, 257 of Vol. IV; likewise his Memoirs relative to the electricity of the atmosphere, of vegetables, of microscopic animals, etc., etc., alluded to in *Journal de Physique* for 1773, 1784, 1788; in *Journal de Paris* for 1784, 1785; in Vol. I of Lazaro Spallanzani's "Opuscoli di fisica," etc., for 1776; in Vol. III of the "Opuscoli Scelti di Milano," and in the *Philosophical Transactions*. See also Jean Senebier, "Mémoire historique," etc., Genève, 1801; Louis Cotte in his "Traité," etc., "Mémoires," etc., "Observation," etc., Paris, 1762, 1769, 1772; in the "Mémoires de Paris," Année 1769, "Hist.," p. 19; Année 1772, "Hist.," p. 16, and in the *Journal de Physique* for 1783, Vol. XXIII; the experiments of MM. Becquerel and Brachet in Becquerel's "Traité d'El. et de Magn.," Paris, 1836, Vol. IV. p. 110; Theodor Ægidius von Heller, "Beobach d. Atmosphär. Elektricität." (F. A. C. Gren, "Neues Journal der Physik for 1797, Vol. IV); Faujas de St. Fond, "Description," etc., Vol. II. p. 271, as per George Adams' "Essay on Electricity," London, 1799, p. 419; Noad, "Manual," etc., London, 1859, p. 16; Poggendorff, Vol. II. p. 755; Rozier, XXXI. pp. 317, 374; XXXIV. p. 161; articles "Meteorology and Electricity" in the "Encyclopædia Britannica"; Thomas Young, "Course of Lectures," etc., London, 1807, Vol. II. pp. 447, 466–471.

A.D. 1784.—Swinden (Jan Hendrik Van) (1746–1823), who had been made Professor in the University of Franequer at the early age of twenty (1767), and was at this time occupying the Chair of Natural Philosophy and Mathematics at Amsterdam, publishes in

three volumes, at La Haye, his " Recueil de Mémoires sur l'Analogie de l'Electricité et du Magnétisme," etc. (" De Analogia . . ." in Vol. II of the " Neue Abhandl. der Baierischen Akad. Phil."). The latter contains all the essays sent to the Electoral Academy of Bavaria on the subject—" Is There a Real and Physical Analogy Between Electric and Magnetic Forces; and, if Such Analogy Exist, in What Manner Do These Forces Act Upon the Animal Body? "

Van Swinden's essay, which gained him one of the prizes, shows that, in his opinion, the similarity between electricity and magnetism amounts merely to an apparent resemblance, and does not constitute a real physical analogy. He infers from this that these two powers are essentially different and distinct from one another, but the contrary opinion was maintained by Profs. Steiglehuer and Hubner, who contended that so close an analogy as that exhibited by these two classes of phenomena indicated the effects of a single agent, varied only in consequence of a diversity of circumstances.

The eminent professor, Gerard Moll, of Utrecht, has communicated to the Edinburgh *Journal of Science* (1826, Vol. I. part ii. pp. 197–208) a biographical notice of Van Swinden, wherein he gives a list of the latter's principal works and there speaks of one of his best-known productions in following manner: " The *Positiones Physicæ* (Opusc. Scelti, X. 7), as far as they are published (Harderovici, 1786, Vol. I and Vol. II. part i.), are allowed to rank among the best elements of natural philosophy, and have been found by actual experience to belong to the best sources from which the young student could draw his information on those parts of natural philosophy, and its general principles, as are contained in the first volume and part of the second, which is all that was published. The work itself is on a most extensive plan; and the multifarious avocations which crowded on Van Swinden in Amsterdam delayed the publications, and made him afterward abandon all thoughts of completing a work which would have done the greatest honour to its author, and which even now, unfinished as it is, is celebrated as an excellent specimen of sound reasoning and profound learning."

Van Swinden was the first President of the Royal Institute of the Netherlands. He entered with ardour into all the new discoveries of his day and kept up an extensive correspondence with many of the leading scientific characters of the time, notably with the Swiss philosopher, Charles Bonnet (whose " Contemplations de la Nature " he annotated extensively); with Dr. Matthew Maty (who became secretary of the Royal Society upon the resignation of Dr. Birch in 1765, and who was appointed, by the king, principal librarian of the British Museum upon the death of Dr. Gowin Knight, 1772); with the eminent French physician, Michel-Augustin

Thouret, Dean of the Paris "Faculté de Médecine"; as well as with Delambre, Euler, De Saussure, and many others who have been named elsewhere in this "Bibliographical History."

The following is further extracted from Prof. Moll's interesting paper: "Mr. Biot, in his treatise on Natural Philosophy (Tome III. p. 143) asserts that we are indebted to Cassini IV. (see Jean Dominique, Comte de Cassini, at A.D. 1782–1791) for much of what we know even about the diurnal variation of the needle. This, I think, is not fair. We do not mean to undervalue Mr. Cassini's observations, but it is unquestionable that long before the publication of that philosopher's work, Mr. Van Swinden had observed and published ('Recherches sur les aiguilles aimantées et leurs variations'—Mémoires présentés à l'Académie des Sciences de Paris, Tome VIII—prize essay 1777) that which Mr. Biot less accurately is pleased to ascribe to his countryman. In this respect, however, Mr. Van Swinden was treated with more justice by other eminent philosophers, such as Haüy, Halley and Burkhardt." (Consult also the "Acta Acad. Petrop." for 1780, Part I. Hist. p. 10.)

In the aforenamed very meritorious work, "Recueil de Mémoires," etc., crowned by the Bavarian Academy, Van Swinden has treated fully of the then current theories relative to electrical and magnetical phenomena, reviewing the entire field of their application. In so doing he has necessarily made numerous references to discoverers and experimenters of all countries, the names of many of which appear in the present compilation, and while it is, of course, useless here to quote these anew, it has been thought best, for a record, to specify such as are infrequently met with, and which appear in many of his most important articles, even at the risk of being accused of diffuseness or prolixity. They are as follows:

REFERENCES.—John T. Needham (Vol. IV, Mem. Brussels Acad. for 1783); *Phil. Trans.*, 1746, p. 247; J. G. Lehmann ("Abhandlung von Phosph."; "Von Magnet Theilen im Sande," "Novi Com. Acad. Petrop.," Vol. XII. p. 368, etc.); M. De La Cépède, "Essai sur l'El. nat et artif."; C. E. Gellert ("Com. Acad. Petrop.," Vol. XIII. p. 382, Exp. 15, 16); J. F. Henckel, "Pyritologia," etc.; J. E. Von Herbert, "Theor. Phæn. Elect.," cap. 4, prop. 8; C. F. M. Déchales, "Mundus Mathematicus," lib. 1, *Quartus Exper. Ordo.*, exp. 16, Tome II. p. 488, ed. 2, etc.; M. Marcel's Dissertation on powdered magnets, which appears in the Dutch "Uitgezogte Verhandelingen," Vol. I. p. 261, etc.; Jean M. Cadet ("Nova Acta. Physico. Med. Acad. Natur. Curios.," Tome III); Abbé Giraud-Soulavie ("Comment. . . . Œuvres de Mr. Hamilton," note 4, p. 303); J. B. Le Roy ("Mém. de l'Acad. de Paris," for 1753, p. 447; for 1772, p. 499; *Jour. de Phys.*, Vol. II); Rudolph Richard ("Magazin d. Hamb.," IV. p. 681); Gilles A. Bazin, "Descrip. des Cour, Mag.," Plates 14, 16–18; J. F. Gross, "Elektrische Pausen," Leipzig, 1776; *Jour. de Phys.*, Vol. X. p. 235; Niccolò Bammacaro, "Tentamen de vi Electrica," etc., s. 6; Samuel Colepress (*Phil. Trans.*, 1667, No. 27, Vol. I. p. 502); E. F. Du Tour, "Discours sur l'aimant,"

s. 27; "Recueil des Prix de l'Acad. de Paris," Tome V. mém. ii. p. 49; "Mém. Math. et Phys."; Mr. Calendrin, at Van Swinden's, Vol. I. pp. 233, etc.; M. Blondeau ("Mém. de l'Acad. de Marine," Brest., Tome I. s. 46, pp. 401–431, 438); J. A. Braun, "Observations," etc.; "Novi. Comment. Acad. Petrop.," Vol. VII. pp. 388, 407; M. Antheaulme ("Mém. sur les aimants artif." (prize essay), 1760; "Mém. de l'Acad. Roy.," 1761, p. 211; Van Swinden, 1784, Vol. II. pp. 95, 170); J. N. Reichenberger, "Directorium magneticum magneticis," etc., and "Hydrotica," as at Van Swinden, 1784, Vol. II. pp. 272–273; Geo. C. Schmidt, "Beschr., einer Elektrisir Masch.," etc., 1778; M. De la Folie (*Jour. de Phys.*, 1774, Vol. III. p. 9); Cölestin Steiglehner, "Obs. phaenom. elect.," "Ueber die Annal der Elek. und des Magn."; Lorenz Hubner, "Abh. u. d. Annal. u. mag. Kraft"; Jos. Thad. Klinkösch, "Schreiben," etc., "Beschreib. d. Volta . . . Elektrophors." Reference should also be made to Noad, "Manual," etc., p. 641; Encycl. Brit., 1857, Vol. XIV. p. 6; "Messager des Sciences et des Arts," Gand, 1823, pp. 185–201, detailing all of Van Swinden's works; Antoine Thillaye's treatise presented to the Ecole de Médecine le 15 Floréal, An. XI; Butet ("Bull. des Sc. de la Soc. Philom.," No. 43, Vendémiaire, An. IX).

A.D. 1784.—Cotugno (Domenico), Professor of Anatomy at Naples, thus addresses Le Chevalier G. Vivenzio under date October 2, 1784: "The observation which I mentioned some days ago, when we were discoursing together of the electrical animals, upon which I said I believed the mouse to be one of that number, is the following: Toward the latter end of March, I was sitting with a table before me and observing something to move about my foot, which drew my attention. Looking toward the floor I saw a small domestic mouse, which, as its coat indicated, must have been very young. As the little animal could not move very quick, I easily laid hold of it by the skin of the back and turned it upside down; then with a small knife that laid by me, I intended to dissect it. When I first made the incision into the epigastric region, the mouse was situated between the thumb and finger of my left hand, and its tail was got between the last two fingers. I had hardly cut through part of the skin of that region, when the mouse vibrated its tail between the fingers, and was so violently agitated against the third finger that, to my great astonishment, I felt a shock through my left arm as far as the neck, attended with an internal tremor, a painful sensation in the muscles of the arm, and such giddiness of the head, that, being affrighted, I dropped the mouse. The stupor of the arm lasted upward of a quarter of an hour, nor could I afterwards think of the incident without emotion. I had no idea that such an animal was electrical; but in this I had the positive proof of experience." (See G. Vivenzio, "Teoria e pratica della elettricità med." . . . Napoli, 1784.)

Cotugno's observations attracted much attention throughout Italy and gave rise to many experiments, notably by Vassalli, who, however, merely concluded from them that the animal's body could retain accumulated electricity in some unaccountable manner.

References.—*Essai sur l'histoire*, etc., J. B. Biot, p. 9; *Journal de Physique*, XLI. p. 57; *Mémoires Récréatifs*, etc., par Robertson, Paris, 1840, Vol. I. p. 233; Cavallo, *Electricity*, London, 1795, Vol. III. p. 6; Izarn, *Manuel*, Paris, 1804, p. 4; *Journal Encyclopédique de Bologne*, 1786, No. 8; Poggendorff, Vol. I. p. 417; Sue, aîné "Hist. du Galv.," Vol. I. pp. 1–2.

A.D. 1785.—Coulomb (Charles Augustin de), the founder of *electro-statics* and of the school of experimental physics in France, invents the torsion balance, with which he discovers the true law of electric and magnetic attractions and repulsions. Some have asserted that Lord Stanhope had previously established the law with regard to electricity, but it has not been seriously questioned that its extension to magnetism belongs exclusively to Coulomb. Johann Lamont ("Handbuch . . ." p. 427) gives the credit of the latter discovery to Giovannantonio Della Bella, of Padua, who is mentioned by Poggendorff ("Biog.-Liter. Handwörterbuch," Vol. I. p. 139) as the author of several works on electricity and magnetism, but the claim does not appear to be established upon any satisfactory foundation.

With his torsion balance, or rather electrometer, Coulomb measured the force by the amount of twist it gave to a long silken thread carrying a horizontal needle, constructed, preferably, of a filament of gum-lac or of straw covered with sealing-wax. From his experiments he concluded: That the attractive force of two small globes, one electrified positively and the other negatively, is in the inverse ratio of the squares of the distances of their centres, and that the repulsive force of two small globes, charged either with positive or negative electricity, is inversely as the squares of the distances of the centres of the globes ("Mém. de l'Acad. Roy. des Sciences," 1784, 1785).

In one of his three memoirs to the French Academy during 1785, he states that a balance used by him was so delicate that each degree of the circle of torsion expressed a force of only one hundred-thousandth of an English grain, that another, suspended by a single fibre of silk four inches long, made a complete revolution with a force of one seventy-thousandth of a grain, and turned to the extent of a right angle when a stick of sealing-wax, which had been rubbed, was presented to it at the distance of a yard. It is said that a similar electrometer has been constructed in which the movement of one degree recorded a force not exceeding twenty-one million six-hundred-thousandths of a grain.

The many valuable experiments made by Coulomb on the dissipation of electricity and upon the distribution of electricity upon the surfaces of bodies are fully recorded in the able article of Sir David Brewster in the "Encyclopædia Britannica" (F. C. Achard,

"Mém. de Berlin," 1780, p. 47); M. Vernier, "De la dist. . . . conducteurs," Paris, 1824; J. L. F. Bertrand, "Programme d'une thèse . . ." Paris, 1839; D. Bourdonnay, "Sur la dist. . . . conducteurs," Paris, 1840; Ed. A. Roche in "Montp. Acad. Sect. Sciences," Vol. II. p. 115).

He discovered that shellac is the most perfect of all insulators, also that a thread of gum-lac insulates ten times better than a dry silken thread of the same length and diameter: and he established the law that the densities of electricity insulated by different lengths of fine cylindrical fibres, such as those of gum-lac, hair, silk, etc., vary as the square root of the lengths of the fibre.

Besides the communications above alluded to, Coulomb sent to the French Academy, during the years 1786, 1787, 1788 and 1789, many papers upon Electricity and Magnetism, and, up to within two years of his death (1806), he made many notable experiments, especially in magnetism, of which full accounts are given in several of the Mémoires noted at foot. The theory of the two magnetic fluids appeared in his 1789 paper. It is also in this same paper that Coulomb describes his improved method of making artificial magnets by employing compound magnets as first made use of by Gowin Knight and as explained at A.D. 1746. Still further improvements in these were brought about more particularly by the young Flemish scientist, Etienne Jean Van Geuns (1767–1795), by Jean Baptiste Biot (see A.D. 1803), and by the Rev. Dr. Scoresby during the year 1836.

Coulomb found that a steel wire is, by twisting, rendered capable of being nine times more strongly magnetized; that the magnetic power dwells on the surface of iron bodies and is independent of their mass; that the directive force of a magnetized bar reached its maximum when tempered to a bright cherry-red heat at 900 degrees, and that every substance is susceptible of magnetism to a degree of actual measurement. This last important research was communicated by him to the French Institute during the year 1802. His experiments proved that a grain of iron could communicate sensible magnetism to twenty pounds' weight of another substance, and that when even beeswax had incorporated with it a portion of iron filings equal only to the one hundred-and-thirty-thousandth part of its weight it was yet sensibly affected by the magnet.

According to Dr. Thomas Young, Coulomb's improvements in the theory of electricity may be considered as having immediately prepared the way for the elegant inventions of Volta and for the still more marvellous discoveries of Davy. Dr. Young gives reports of some of Coulomb's experiments at p. 439, Vol. II of his "Course

of Lectures," London, 1807 (" Journal of the Royal Institution," Vol. I. p. 134; " Décade Philosophique," No. 21).

REFERENCES.—" Mém. de l'Acad. Royale des Sciences," Paris, 1784, p. 266; 1785, pp. 560, 569, 578, 612; 1786, p. 67; 1787, p. 421; 1788, p. 617; 1789, p. 455; " Mém. de l'Institut," Vol. III. p. 176; Vol. IV. p. 565, and Vol. VI. for 1806; " Mém. de Math. et de Phys." Vols. VIII and IX; " Mémoires de Coulomb," Vol. I of the " Collection de Mémoires relatifs à la Physique," Paris, 1884; " Cat. of Sc. Papers Roy. Soc.," Vol. III. p. 73; " Abstracts of Papers of Roy. Soc.," Vol. II. p. 402; " Bull. de la Soc. Philom.," Nos. 3, 31, 61, 63, and for 1795, 1802; *Journal de Physique*, Vols. XLV (II), pp. 235, 448; LIV. pp. 240, 267, 454; LV. p. 450 (for Carradori's report); Ch. N. A. De Haldat du Lys (" Mém. de Nancy " for 1841); *Phil. Magazine*, Vols. XI. p. 183; XII. p. 278; XIII. p. 401; XV. p. 186; Rozier, XXVII. p. 116; XLIII. p. 247; Gilbert, XI. pp. 254, 367; XII. p. 194; Dr. Young, " Course of Lectures," London, 1807, Vol. I. pp. 682, 685, 686; " Royal Society Cat. of Sc. Papers," Vol. II. p. 73; Eighth " Britannica," Vol. XIV. pp. 37–38; Humboldt, " Cosmos," 1859, Vol. V. p. 61; Schaffner, " Manual," 1859, p. 56; Biot's article in the " Biographie Universelle " and Biot's " Traité de Physique," Paris, 1816, Vols. II, III; Dr. Thomas Thomson, " Outline of the Sciences," etc., London, 1830, pp. 350, 351, 379–422; Harris, " Rudim. Magn.," Parts I, II. p. 56. See also description of the electrometer of Colardeau and the electro-micrometer of Delaunay, in the latter's " Manuel," etc., Paris, 1809, pp. 66, 76–80, and Plate V. fig. 61, as well as Libes' " Dict. de Phys.," Vol. I. p. 406.

A.D. 1785.—The Canon Gottoin de Coma, friend of Alessandro Volta, observes that an iron wire about thirty feet in length will give a sound under certain conditions of the atmosphere when stretched in the open air. The circumstances that accompany, as well as those that favour the production of the phenomenon, says Prescott, demonstrate that it must be attributed to the transmission of atmospheric electricity. This transmission does not occur in a continuous manner, like that of a current, but is observable by a series of discharges.

REFERENCES.—Knight's *Mechanical Dictionary*, 1876, Vol. III. p. 2515; Prescott's " The Speaking Telephone," etc., 1879, p. 122; *Encyl. Britannica*, 1860, Vol. XXI. p. 631.

A.D. 1785.—Marum (Martin Van), a Dutch electrician who had in 1776 taken the degree of M.D. at the Academy of Gröningen, constructs for the Teylerian Society at Haarlem, with the assistance of John Cuthbertson, an electrical machine said to be the most powerful theretofore made. According to Cavallo (*Nat. Phil.*, 1825, Vol. II. p. 194) it consisted of two circular plates of French glass, each sixty-five inches in diameter, parallel with each other on a common axis, and about seven and a half inches apart. Each plate was excited by four rubbers, the prime conductor being divided into two branches which entered between the plates and, by means of points, collected the electric fluid from their inner surfaces only.

In Van Marum's machine, the positive and negative electricity

could only be obtained in succession, but Dr. Hare, of the University of Pennsylvania, remedied this by causing the plates to revolve horizontally. It is said the machine was so powerful that bodies at a distance of forty feet were sensibly affected; a single spark from it melted a leaf of gold and fired various kinds of combustibles; a thread became attracted at the distance of thirty-eight feet, and a pointed wire was tipped with a star of light at a distance of twenty-eight feet from the conductor.

Descriptions of his machines are given by Dr. Van Marum in letters to the Chevalier Marsiglio Landriani and to Dr. Ingen-housz, both printed in Haarlem during 1789 and 1791. The first quarto volume of *Nicholson's Journal* also contains a reference thereto and gives (p. 83) the extract from a letter read June 24, 1773 (*Phil. Trans.*, Vol. LXIII. pp. 333–339), addressed to Dr. Franklin, F.R.S., by John Merwin Nooth, M.D., who describes improvements by which machines are rendered effective in all kinds of weather. Nooth was the inventor of the silk flap, of which mention was made in the description of Cavallo's machine (under A.D. 1775).

Van Marum also constructed a powerful battery, the metallic coatings of which were equal to 225 square feet, enabling him to give polarity to steel bars nine inches long, nearly half an inch wide and one-twelfth of an inch thick, as well as to sever a piece of boxwood four inches diameter and four inches long, and to melt three hundred inches of iron wire one hundred-and-fiftieth of an inch in diameter, or ten inches of one-fortieth of an inch in diameter. It is said that, during these experiments, the report was so loud as to stun the ears, and the flash so bright as to dazzle the sight.

Dr. Van Marum likewise made experiments upon the electricity developed during the melting and cooling of resinous bodies, which are detailed in the article "Electricity," 8th Edit. "Encyclopædia Britannica," Vol. VIII. p. 565, and also upon the effects of electricity on animals and vegetables, which are given at pp. 49–51 of the article "Electricity" in the "Library of Useful Knowledge," as well as in the 1855 Edit. "Encyclopædia Britannica," Vol. VIII. pp. 602, 603.

In 1785 again Van Marum discovered that electric sparks, on passing through oxygen gas, gave rise to a peculiar sulphurous or electrical odour, which Cavallo called "electrified air," and the presence of which Dr. John Davy, brother of Sir Humphry Davy, found the means of detecting.

During the month of October 1801 Volta wrote a letter to Van Marum asking him to make, in concert with Prof. C. H. Pfaff, of Kiel, several experiments on the electricity of the pile with the very powerful apparatus of the Teylerian Society. The extended

researches of these two scientists are embodied in the *Phil. Mag.*, Vol. XII. p. 161, as well as in the "Lettre à Volta," etc., published at Haarlem during 1802, and are likewise treated of in a very complete manner throughout Chaps. XVI and XXXII of Wilkinson's well-known work on galvanism. Their united observations confirm the doctrine of Volta as to the identity of the current of the fluid put in motion by the voltaic pile and that to which an impulsion is given by an electrical machine. Thus is answered the question asked during May 1801 by the Haarlem Society of Sciences, viz. "Can the voltaic pile be explained in a satisfactory manner by the known laws and properties of electricity; or is it necessary to conclude the existence of a particular fluid, distinct from the one which is denominated electrical?" They also demonstrated that the current put in motion by the voltaic pile has an enormous celerity "which surpasses all that the imagination can conceive." With a pile of one hundred and ten pairs of very large copper and zinc plates, they made experiments on the fusion of iron wires and ascertained the causes of the more considerable effects of large piles in the fusion and oxidation of metals, proving, among other facts, as Biot and Cuvier had already done, that a part of the oxygen is absorbed whether the operation be carried on in the open air or *in vacuo* (Biot and Cuvier, *Soc. Philomathique,* An. IX. p. 40; *Annales de Chimie,* Vol. XXXIX. p. 247).

Another of Van Marum's experiments is related in a letter to M. Berthollet. wherein he says: " . . . I have succeeded in the decomposition of water, by means of the current of the electrical machine, provided with a plate of thirty-one inches diameter, constructed by me on a new plan (see the *Journal de Physique* for June, 1795). . . . I took a thermometrical tube, of the kind employed in making the most sensitive thermometers of Crawford and Hunter, for which purpose I had procured several of these tubes some time before in London. Its diameter interiorly was not more than the one-hundredth part of an inch; and I introduced into it an iron wire of the diameter of about the three-hundredth part of an inch, to the depth of about twelve inches. I now closed the end of my thermometrical tube with sealing wax in such a way that the extremity of the iron wire should scarcely project, and I placed the tube itself, by means of a cork, within a larger tube containing water. The rest of the apparatus was arranged in the customary manner. By directing the powerful current of the above-mentioned machine to this apparatus, the copper ball belonging to which, placed on the thermometrical tube, was at the distance of about three or four lines from the conductor, I succeeded in decomposing the water with a promptitude nearly equal to that which results from a voltaic pile

of a hundred pairs of metallic plates." This method of decomposing water is a very tedious one, and is in fact the result of an interrupted explosion, while the process of Dr. Wollaston (alluded to at A.D. 1801) is tranquil and progressive.

REFERENCES.—" Biogr. Univ.," Vol. XLII. p. 600; J. G. Heinze, " Neue elekt. versuche . . ." Oldenberg, 1777; Tries' claim to Van Marum's machine in Rozier, XL. p. 116; Prieur's extract in *Annales de Chimie*, Vol. XXV. p. 312; " Verhand. Genootsch. Rott.," VI for 1781 and VIII for 1787; *Journal de Physique*, XXXI, 1787; XXXIII, 1788 (Marum en Troostwyk); XXXIV, 1789; XXXVIII, 1791; XL, 1792; " Journal du Galvanisme," XI, Cahier, p. 187; " Journal des Savants " for August 1905; " Revue Scientifique," Paris, April 8, 1905, pp. 428–429; *Nicholson's Journal* for March 1799, Vol. II. p. 527; Harris, " Electricity," pp. 62, 90, 171; Cuthbertson, " Practical Electricity," London, 1807, pp. 166, 172, 197, 225; Cavallo, " Electricity," 4th ed., Vol. II. p. 273; " Lib. of Useful Knowledge," "Electricity," p. 45; Wilkinson, " Elements of Galvanism," etc., London, 1804, Vol. II. pp. 106–128, 384; " Teyler's Tweede Genootschap "; Gilbert, *Annalen*, I. pp. 239, 256; X. p. 121; Rozier, XXVII. pp. 148–155; XXXI. p. 343; XXXIV. p. 274; XXXVIII. pp. 109, 447; XL. p. 270; " Opus. Scelti," IX. p. 41; XIV. p. 210.

A.D. 1785.—Sigaud de la Fond, Professor at the Collège d'Harcourt in Paris, publishes in the latter city his " Précis historique et expérimental des phénomènes electriques," wherein he states having, as far back as 1756, made use of a circular plate machine provided with cushions and similar in shape to that which many claim to have originated with Ingen-housz and with Ramsden. (See A.D. 1779 and A.D. 1768.)

Sigaud de la Fond is also the author of " Description d'un Cabinet de Physique " (1784), " Cours de Physique," etc. (1786), "Examen.," etc. (1803) and of several treatises on medical electricity.

REFERENCES.—" Journal de Physique," Vol. II. 1773; Figuier, " Exposition et Histoire," Paris, 1857, pp. 50, 74–76, 178; Poggendorff, Vol. II. p. 927.

A.D. 1785.—In the " Nachricht von einer neuen Elektrisirmaschine des Herrn Walkiers von Saint Amand," the last named gives a description of the electrical machine presented by him in 1784 to the Belgian Academy of Sciences.

It is also described and outlined in Delaunay's " Manuel " named below, but, although very powerful in its effects, cannot be made readily available in consequence of its huge dimensions. M. Caullet de Veaumorel suggested the feasibility of changing the cylinders from a horizontal to a vertical position.

REFERENCES.—" Lichtenberg's Mag.," Vol. III. 1 st. p. 118; Delaunay, " Manuel," etc., 1809, pp. 14–16.

A.D. 1785.—Adams (George), mathematical instrument maker to his Majesty, writes an enlarged edition of his " Essay on Electricity,"

etc., which first appeared the year previous and wherein, as its full title indicates, he endeavours to explain the theory and practice of that science and the mode of applying it to medical purposes. He illustrates many experiments and gives an Essay on Magnetism, in the treatment of which latter he acknowledges the valuable aid of Dr. J. Lorimer.

The fifth and last edition of the "Essay," which was issued by William Jones in 1799, four years after Adams' death, contains a communication on the subject of Medical Electricity by John Birch, the author of "Della Forza dell' Elettricita," etc., Napoli, 1778.

At p. 86 of the 1799 "Essay," etc., Adams relates that, while M. Loammi Baldwin ("Memoirs of Amer. Acad.," Vol. I. p. 257) held the cord of his kite during the approach of a thunderstorm, he "observed himself to be surrounded by a rare medium of fire, which, as the cloud rose nearer the zenith, and the kite rose higher, continued to extend itself with some gentle faint flashes." At pp. 137, 186 and 222, he alludes to "A. Brook's Miscellaneous Experiments and Remarks on Electricity," etc., as well as to the Rev. John Lyon's "Experiments and Observations of Electricity," and refers to the "Journal of Natural Philosophy" (Vol. II. p. 438) for Nicholson's experiments on the *plus* and *minus* of electricity.

A.D. 1785.—La Méthérie (Jean Claude de), French physicist naturalist, becomes sole editor of the "Journal de Physique, de chimie et d'histoire naturelle," and publishes in Paris his "Essai Analytique," etc., wherein amongst other observations he asserts that the electric spark results from the combination of oxygen with hydrogen.

He considers that all bodies exist in an electrical or magnetical condition, that we are only a temporary aggregation of molecules of matter governed in different ways by nature's laws, and that excitability is produced by galvanic action resulting from the superposition of nervous and muscular fibres.

He is also the author of very interesting treatises on animal electricity communicated to the *Journal de Physique* (Vol. XLII. pp. 252, 255, 292), and of which an account is given in Sue's "Histoire du Galvanisme," Paris, 1802, Vol. I. pp. 64–68. The last-named work also gives, at p. 80, an account of the letter on "Galvanism" sent to M. De La Méthérie by M. Leopold Vacca-Berlinghieri (*Journal de Physique*, Vol. XLI. p. 314).

References.—"Biographie Générale," Vol. XXIX. p. 209; Rozier, XLI. p. 437; Delaunay, "Manuel," etc., 1809, p. 15, also Delaunay's letter in *Phil. Mag.*, Vol. XXVII. p. 260; C. H. Wilkinson, "Elements of Galvanism," London, 1804, Vol. I. p. 62; Vol. II. p. 9; "Opus. Scelti," XXI. p. 373; *Journal de Physique et Chimie* (of which La Méthérie remained

editor up to the time of his death, during 1817), Vols. LIII, LIV, Pluviose, An. XI. p. 161; also p. 157 for letter sent him by Giuseppe Izarn; *Ann. di Chim. di Brugnatelli*, Vol. XIX. p. 156; Aubert, "Elektrometische Flasche," Paris, 1789.

A.D. 1785.—According to Prof. Tyndall, George Cadogan Morgan sought to produce the electric spark in the interior of solid bodies. He inserted two wires into wood and caused the spark to pass between them; the wood was illuminated with blood-red light or with yellow light according as the depth at which the spark was produced proved greater or less. The spark shown within an ivory ball, an orange, an apple, or under the thumb, illuminates these bodies throughout. A lemon is especially suited to this experiment, flashing forth, at every spark, as a spheroid of very brilliant golden light, and a row of eggs is also brilliantly illuminated throughout, at the passage of every spark from a Leyden jar. Morgan likewise made several experiments to ascertain the influence of electricity on the animal functions. These are alluded to at p. 602, Vol. VIII of the 1855 "Britannica," and at p. 49 of "Electricity" in the "Library of Useful Knowledge."

This George Cadogan Morgan (1754–1798) was an English physician and also a Professor of Natural Philosophy at Hackney, in an establishment founded by his uncle, Dr. Price. His "Lectures on Electricity" appeared in Norwich during the year 1794. In the second volume he describes (pp. 225–236) "the form, noise, colours and devastation of the electric flash," and treats (pp. 383–397) of the "relation of the electric fluid to vegetation," alluding more particularly to the experiments of Maimbray, Nollet, Achard, Duvernier, Ingen-housz, Van Breda, Dr. Carmoy and the Abbé d'Ormoy. He likewise gives an account of the northern lights, as well as descriptions of Bennet's movable doubler and electroscope, and of Lane's electrometer.

REFERENCES.—Morgan's biography in Larousse, "Dict. Universel," Tome XI. p. 562, and in "Biog. Générale," Tome XXXVI. p. 570; "Bibl. Britan." An. VII. vol. ii. pp. 129, 223, and Vol. XII. p. 3.

A.D. 1786.—Rittenhouse (David), an American physicist and astronomer who afterward became F.R.S. and succeeded Dr. Franklin as President of the Am. Philos. Soc., publishes his theory of magnetism in a letter to John Page at Williamsburg, which is reproduced at folio 178 of Vol. II, old series, of the Transactions of the above-named Society.

"Were we called upon," says Renwick, "to assign him a rank among the philosophers whom America has produced, we should place him, in point of scientific merit, as second to Franklin alone."

REFERENCES.—"Trans. Am. Phil. Soc.," Vol. II, O.S., pp. 173, 175, for Page and Rittenhouse, and Vol. III. for Rittenhouse and Jones, as well as Rittenhouse and Hopkinson, upon "Meteors and Lightning."

A.D. 1786.—Galvani (Aloysio or Luigi), an Italian physician, who, at the age of twenty-five, was Professor of Anatomy at the University of Bologna, is led to the discovery of that important branch of electricity which bears his name. The manuscript giving the result of his experiments upon the Electricity of Metals is dated Sept. 20, 1786.

From papers in the "Bolognese Transactions," noted below, it would appear that he had, even before the year 1780, made many observations on the muscular contraction of frogs by electrical agency. Upon one occasion his wife happened to be holding a scalpel against the dissected legs and parts of the spine of a frog, which lay in close proximity to the conductor of an electrical machine recently charged by one of Galvani's pupils. She noticed that whenever the dissecting knife touched the muscles they were violently convulsed, and, upon communicating the fact to her husband, he repeated and extended the experiment and found it necessary to pass the electric fluid through a metallic substance in order to develop the result originally observed. At first the frogs had been hung upon a copper hook fastened to an iron railing, but he afterward substituted an arc composed of both metals and with which he could readily produce the same results as were obtainable with an electrical machine.

Galvani also made experiments to ascertain the effect of atmospheric electricity upon the nerves of frogs. He connected the latter with rods leading to lightning conductors erected upon the roof of his house, attaching also ground wires to the legs of the animals, and found that the same convulsions appeared whenever lightning was seen and likewise when heavy storm clouds passed over the house.

The results of his many interesting observations were first made public in the celebrated work entitled "Aloysii Galvani de viribus electricitatis in motu musculari. Commentarius: cum Aldini dissertatione et notis," which appeared during 1791–1792. Therein, he expresses the belief that the bodies of animals possess a peculiar kind of electricity by which motion is communicated through both nerve and muscle, positive electricity going to the nerve, while negative electricity goes to the muscle, and that the muscles represent the exterior and the nerves the interior of the Leyden jar, the discharge being similarly produced by the metal which communicates with both.

Galvani's singular experiments naturally attracted everywhere

the attention of philosophers, by whom they were repeated and varied, but by none were they more assiduously prosecuted than by Volta, who was then a Professor at the Pavia University, and who, as already indicated, was led by them to the discovery of the voltaic pile and of voltaic or galvanic electricity.

The announcement of Galvani's observations was made in Germany, notably by J. F. Ackermann (" Medicinisch-chirurgische Zeitung "), by M. Er (" Physiologische Darstellung der Lebenskräfte "), by M. Smuck (" Beiträge zur weiteren Kenntniss," etc.), and by F. A. C. Gren (" Journal der Physik," Vols. VI, VII and VIII), while experiments were continued upon an extensive scale by the Italians F. Fontana, Carlo Francesco Bellingeri, M. Giulio and F. Rossi, as well as by Samuel T. Von Sömmering, by Wilhelm Behrends and by Karl Friedrich Kielmayer (Kielmaier), Professor of Medicine at the Tübingen University (Poggendorff, Vol. I. p. 1253). For the curious galvanic experiments of the celebrated French physician Larrey, and of Stark, Richerand, Dupuytren and Dumas, see " Bulletin des Sciences de la Société Philomathique," 1793, Nos. 23, 24, and " Principes de Physiologie," Vol. II. p. 312.

References.—C. Alibert, " Eloges Historiques de Galvani, Spallanzani, Roussel et Bichat . . ." Paris and Bologna, 1802–1806 (" Mém. de la Soc. d'Emul. de Paris," Vol. IV; S. Gherardi, " Rapporto sui Manoscrotti," Bologna, 1840, p. 19); Poggendorff, Vol. I. p. 839; Thomas Thomson, " History of the Royal Society," London, 1812, pp. 450, etc.; Thomas Young, " Course of Lectures," London, 1807, Vol. II; " Bolognese Transactions " for papers dated April 9, 1772, April 22, 1773 and Jan. 20, 1774; Sabine, " El. Tel.," 1872, pp. 16–18; Knight's " Mech. Dict.," Vol. II. pp. 936, 937, for extract from report of Nat. Inst. of France, July 4, 1798; " Johnson's Encyclop.," 1877, Vol. I. p. 1510; Bakewell's " Electricity," p. 26; " Encyclop. Britannica," 1855, Vol. VIII. p. 530, and Vol. XXI. pp. 609, etc.; Fahie's " History," etc., 1884, pp. 180–185; *Phil. Trans.*, 1793; Miller, " History Philos. Illustrated," London, 1849, Vol. IV. p. 333; Thomson, " Hist. of Chemistry," Vol. II. pp. 251, 252; Matteucci, " Traité des phénomènes," etc., Part I. p. 7; the Address of M. Gavarret made in 1848 before the Paris Medical Faculty; J. C. I. A. Creve's treatise on Galvanism (" Jour. de la Soc. de Méd.," Vol. XVIII. p. 216); " Mém. de la Soc. Méd. d'Emul.," Vol. I. p. 236); Biot et Cuvier (*Ann. de Ch.*, Vol. XXXIX. p. 247); A. Richerand (" Mém. de la Soc. Méd. d'Em." Vol. III. p. 311); " Opus. Scelt.," Vol. XV. p. 113; " Giornale Fis. Med.," Vol. II. pp. 115, 131 (letter of B. Carminati); Marsiglio Landriani, " Lettera," etc., 1776; Lettre d'un ami au Comte Prosper Albo (" Bibl. de Turin," 1792, Vol. I. p. 261; *Jour. de Phys.*, Tome XLI. p. 57); " Comment Bonon. Scient.," Vol. VII. p. 363; account of the experiments made by MM. Cortambert and Gaillard, reported in " Mém. de la Soc. Méd. d'Em.," Vol. I. pp. 232, 235; G. Klein's " Dissert. de Métal," etc., Maintz, 1794; Ostwald's *Klassiker*, No. 52, p. 4; C. H. Wilkinson, " Elements of Galvanism," etc., London, 1804, 2 Vols. *passim ;* Wm. C. Wells, " Obs. on the Influence," etc. (*Phil. Trans.*, 1795, Pt. XI. p. 246); E. G. Robertson (*An. de Ch.*, 1801, Vol. XXXVII. p. 132; *Jour. de Paris*, 10, 15 and 17 Fructidor de l'An. VIII); Paul Louis Simon, " Beschreibung neuengalvanisch," etc., " Resultate," etc., and " Versuche," etc., all published in 1801 (L. W. Gilbert's *Annalen*, 1801, Book V, *An. de Chimie*, No. 121, p. 106); L. W. Gilbert's Book VI of the

Annalen, containing the "Memoirs on Galvanism," by J. L. Boeckmann, L. A. von Arnim, Paul Erman, M. Gruner and C. H. Pfaff; C. Dupuytren, "Faits Particuliers," etc., 1801; J. B. Trommsdorff, "Expér. Galv.," 1801; M. Rouppe's letter of Aug. 28, 1801, in Van Mons' *Jour. de Ch.*, Vol. I. pp. 106, 108; M. Bichat (Sue, "Hist. du Galv.," II. p. 216); A. M. Vassalli-Eandi (*Jour. de Phys.*, Frimaire, An. X. p. 476); C. F. Hellwag and M. Jacobi fils, "Erfahrungen," etc., 1802; M. le Comte de Pusckin's experiments on Galvanism, made Sept. and Dec. 1801, with a *colonne tournante* (Sue, "Hist. du Galv.," Vol. II. pp. 257, 258); Al. Volta, in *Jour. de Leipzig*, and in "Comment . . . Med. gestis," 1792; Johann Mayer, "Abh. . . . Galvani, Valli, Carminati u. Volta . . ." Prag, 1793); Junoblowiskiana Society ("Comment . . . Med. gestis," 1793); "Imperial Dictionary of Universal Biography," Wm. McKenzie London, n. d., Vol. II. p. 546; M. Cortambert ("Mém . . . Soc. . . . d'Emul.," I. p. 232); M. Payssé ("Jour. de la Soc. des Pharm.," first year, p. 100); Geo. Couvier (*Jour. de Physique*, Vol. VII. p. 318; "Mém. des Soc. Sav. et Lit.," Vol. I. p. 132), 1801; C. Mathieu ("Rec. de la Soc. d'Agr. . . . d' Autun," An. X. p. 21), 1802; Ponton d'Amécourt, "Exposé du Galvanisme," Paris, 1803; Joseph Weber's works, published in 1802–1803, 1815, 1816, and those of J. K. F. Hauff, Marburg and Leipzig, 1803, 1804; M. Curtet (*Jour. de Van Mons.*, No. VI. p. 272; *Jour. de Physique*, An. XI. p. 54), 1803; William Meade ("On the origin and progress of Galvanism"), Dublin, 1805; J. C. Reil (*Jour. de Van Mons.*, No. IV. p. 104; Sue, "Hist. du Galv.," Vol. IV. p. 26); J. A. Heidmann (*Phil. Mag.*, Vol. XXVIII. p. 97), 1807; Sir Richard Phillips, "Electricity and Galvanism explained . . ." (*Phil. Mag.*, Vol. LVI. p. 195), London, 1820; B. G. Sage, "Recherches . . . Galvanisme"; Leopold Nobili, "Sur le courant. . . ." Genève, 1827.

A.D. 1786.—Hemmer (J. J.), celebrated physician and secretary of the Meteor. Society of Mannheim, gives, in the "Transactions of the Electoral Society," an account of what have been pronounced the most complete series of experiments ever made upon the electricity of the human body. They absolutely show that the human subject possesses no species of electrical organs which are under the regulation of the will. Of his many observations, the following are worth recording: He found that the electricity of the body is common to all ages and sexes; that its intensity and character often vary in the same body (in 2422 experiments, it was 1252 times positive, 771 times negative and 399 times imperceptible); that the electricity of the body is naturally positive, it being always so when subject to no violent exertion, and that when the body is subjected to sudden or violent motion the electricity becomes negative, the case also when the body experiences either cold or extreme lassitude.

References.—"Encycl. Brit.," Vol. VIII, 1855, p. 571; "Rheinische Beiträgen zur Gelehrsamkeit" for 1781, Fifth Book, pp. 428–466; Van Swinden, "Recueil," etc., La Haye, 1784, Vols. I and II *passim*; "Observ. sur la Phys.," July, 1780; *Phil. Mag.*, 1799, Vol. V. pp. 1, 140; "Comment. Acad. Theod.-Palat.," Vols. IV, V and VI of *Phys.*; "Mém. de l'Acad. de Mannheim," Vol. IV; "Pfalzbayr. Beiträge" for 1782.

A.D. 1787.—Lomond—Lomont—(Claude Jean-Baptiste), a very capable French machinist, and "one who has a genius for inven-

tion," is the first to introduce a successful electric telegraph consisting of but one wire. Of this the following account appears under date Oct. 16, 1787, in Arthur Young's " Voyage Agronomique en France " (" Travels "), fourth edition, Vol. I. p. 79 : " You write two or three words on a paper; he takes it with him into an adjoining room and turns a machine in a cylinder case, on the top of which is an electrometer having a pretty little ball of pith of a quill suspended by a silk thread; a brass wire connects it to a similar cylinder and electrometer in a distant apartment, and his wife, on observing the movements of the corresponding ball, writes the words which it indicates. From this it appears that he (Lomond) has made an alphabet of motions. As the length of the brass wire makes no difference in the effect, you could correspond with it at a great distance, as, for example, with a besieged city or for objects of much more importance. Whatever be the use that shall be made of it, the discovery is an admirable one."

References.—Ed. Highton, " Elec. Tel.," 1852, p. 38; Sabine, " Elec. Tel.," pp. 10–11; Shaffner, " Manual," pp. 132, 133; Vail's " History," etc., p. 121; " Appleton's Encycl.," 1871, Vol. XV. p. 335.

A.D. 1787.—Brard (Cyprien Prosper), French mineralogist, first observes that some crystals of axinite (consisting mainly of silica, alumina, lime and peroxide of iron) become electric by heat.

References.—Gmelin, article " Elecricity," etc., Vol. I. p. 319; Larousse, " Dict. Univ.," Vol. II. p. 1205; Thomas, " Dict. of Biog.," Vol. I. p. 429; " Enc. Brit.," 8th ed., Vol. VIII. p. 530; Brard, " Manuel du Minéralogiste," etc., Bordeaux Academy of Sciences Report for 1829, p. 39, and for 1838, p. 84—the latter containing M. Hatchett's observations on one of M. Brard's meteorolites.

A.D. 1787.—Haüy (Le Père René Just), native of Picardie and member of the Académie Royale des Sciences, publishes an abridgment of the doctrines of Æpinus (at A.D. 1759) under the title of " Exposition raisonnée de la Théorie de l'Electricité et du Magnétisme." He was doubtless the first to observe that in all minerals the pyro-electric state has an important connection with the want of symmetry of the crystals, and no proof of the extent to which he directed his investigations in that line can more readily be had than by consulting general " Encyclopædia " articles relative to the pyro-electricity of boracite (borate of magnesia), of prehnite (silica, alumina and lime), of mesotype (hydrated silicate of alumina and of lime or of soda), of sphene (silica, titanic acid and lime), calamine (silicate of zinc) and of Siberian topaz.

At pp. 480, 481 of his " Outline of the Sciences," etc., London, 1830, Dr. Thomas Thomson states :

" There is a hill of sulphate of lime, called Kalkberg, situated near

Lunebourg, in the duchy of Brunswick, in which small cubic crystals are found. These cubes are white, have a specific gravity of 2·566, and are composed of two atoms of boracic acid combined with one atom of magnesia. They are distinguished among mineralogists by the name of *boracite*. If we examine the cubic crystals of boracite, we shall find that only four of the solid angles are complete, constituting alternate angles placed at the extremity of two opposite diagonals at the upper and lower surface of the cube. The other four solid angles are replaced by small equilateral triangles. When the boracite is heated all the perfect solid angles become charged with *negative* electricity, while all the angles replaced by equilateral triangles become charged with *positive* electricity. So that the boracite has eight poles: four positive and four negative. Those are obviously the extremities of four diagonals connecting the solid angles with each other. One extremity of each of these diagonals is charged with positive and the other extremity with negative electricity. In general, the electricity of boracite is not so strong as that of the *tourmaline*." This curious law of the excitability of the boracite and of its eight poles was discovered by Haüy in 1791 (Haüy's "Minéralogie," 260, second edition).

Axinite, *mesotype*, and the *silicate of zinc* are also minerals which become electric when heated, and which, like the *tourmaline*, exhibit two opposite poles, the one positive, the other negative. It is not every crystal of axinite and mesotype which possesses this property, but such only as are unsymmetrical, that is to say, such as have extremities of different shapes. No doubt this remark applies also to the silicate of zinc; though as the crystals of that mineral are usually acicular it is not so easy to determine by observation the degree of symmetry which they may possess.

The *topaz*, *prehnite*, and the titaniferous mineral called *sphene* are also capable of being excited by heat, and have two opposite poles like those already mentioned.

Haüy also made the most extensive and accurate observations known upon the development of electricity in minerals by friction. Detailed lists of the different classes of minerals, as well as the conclusions arrived at through various experiments, are given in the "Encyclopedia Britannica," Vol. VIII, 1855, pp. 538, 539, while at pp. 529 and 558 of the same work are to be found accounts of his observations on the electricity of the *tourmaline*, as well as a description of the different electroscopes employed in his many experiments.

REFERENCES.—Priestley, "History of Electricity," 1767, pp. 314–326; Gmelin's "Chemistry," Vol. I. p. 319; Noad, "Manual," pp. 27–31; also article "Electricity" in "Library Useful Knowledge," pp. 3,

54, 56; M. Lister, "Collection Académique," Tome VI; "Société Philomathique," An. V. p. 34; An. XII. p. 191; "Mém. du Museum d'Hist. Nat.," Vol. III; "Mém. de l'Institut," An. IV. tome i., "Sciences Math. et Phys." p. 49; "Mém. de l'Académie," 1785, Mem. p. 206; *Philosophical Magazine*, Vols. XX. p. 120; XXXVIII. p. 81; Thomas Thomson, "Hist. of the Roy. Soc.," London, 1812, pp. 180, etc.; Young's "Lectures," London, 1807, Vol. II; Haüy, "Traité Elémentaire de Physique," Chap VII, "Magnetism"; Experiments of J. L. Treméry (author of "Observations sur les Aimants Elliptiques," recorded in *Journal des Mines*, Vol. VI for 1797, also in *Jour. de Phys.*, Vols. XLVIII and LIV) and of M. De Nelis, some of whose observations are given in the *Phil. Mag.*, Vol. XLVIII. p. 127, and in the *Jour. de Phys.*, Vols. LXI. p. 45; LXII. p. 150; LXIII. p. 147; LXIV. p. 130; LXVI. pp. 336, 456, as shown and illustrated at pp. 153–162 of Delaunay's "Manuel," etc., of 1809; "Séances de l'Acad. de Bordeaux" for 1835, giving M. Vallot's report on the difference existing between the chalcedony and the tourmaline. Regarding the latter, consult S. Rinmann ("K. Schwed. Akad. Abh.," XXVIII. pp. 46, 114); C. Rammelsberg, "Die Zuzam . . . und Feldspaths"; Mr. Magellan's edition of Cronstedt's Mineralogy for Steigliz's tourmaline; Cesare G. Pozzi, on the tourmaline; H. Von Meyer ("Archiv. . . . Ges. Natural," XIV. 3, p. 342); M. Lechman (Berlin Academy Reports); Carl Von Linné (Linnæus), "Flora Zeylanica," Stockholm, 1747; M. Leymerie (Toulouse Acad. Reports); Brewster, "Journal" I. p. 208; J. K. Wilcke ("Vetensk. Akad. Handl.," 1766 and 1768); Jos. Muller, "Schreiben . . . Tourmaline," Wien, 1773; F. J. Muller von Reichenstein, "Nachr. . . . an Born," Wien, 1778; H. B. de Saussure ("Jour. de Paris"), 1784; Louis Delaunay's letter on the tourmaline, 1782; D. G. Fischer's works, published at Mosk, 1813, 1818; J. D. Forbes ("Edin. Trans.," Vol. XIII), 1834.

A.D. 1787.—Charles (Jacques Alexandre César), a singularly able French physicist and experimentalist, who became the Secretary of the Académie des Sciences, relates many of his electrical experiments in the thirtieth volume of the *Journal de Physique.*

He was one of the first to study and develop the theories of Franklin, who, in company with Volta, frequently attended the brilliant lectures which Charles was enabled to give in what was then considered the most complete philosophical laboratory of Europe. In many of his experiments on atmospherical electricity, Charles has been known to produce thousands of sparks, beams or flashes, which exceeded 12 feet in length and which made reports similar to those of fire-arms. The French Academy endorsed the opinion given the Minister of War by Charles to the effect that "a conductor will effectually protect a circular space whose radius is twice the length of the rod."

Charles invented the megascope and was the first to make an ascension in a hydrogen balloon, which he did in company with M. Robert on the 1st of December (not on the 2nd of August) 1783, ten days after the first trip made by Pilatre de Rozier and Comte d'Arlandes in a Montgolfière from the Paris Bois de Boulogne.

References.—"Biographie Générale," Vol. IX. pp. 929–933; Larousse, "Dict. Univ.," Vol. III. p. 1020; *Journal de Physique* for 1791, p. 63; "Mémoires de l'Acad. des Sciences" for 1828; George Adams,

"Lectures on Nat. and Exp. Philosophy," London, 1799, Vol. III. pp. 462–464; Edin. Encycl., 1813, article "Aeronautics," Vol. I. p. 160, "Franklin in France," 1888, Part II. pp. 256, 270, 276–280; M. Veau Delaunay, Introduction to his "Manuel," etc., Paris, 1809, pp. 19, 25 and 61–63; also pp. 23, 68, 92, 96, 122, 176 and 214.

A.D. 1787.—Mann (Théodore Augustin), Abbé, Flemish writer and antiquary, becomes perpetual secretary of the Brussels Academy of Sciences ten years after leaving the Nieuport Monastery (1777), and is charged with the duty of making meteorological observations, which are regularly transmitted to the Mannheim Academy officials, who receive similar reports regularly from different parts of Europe and publish them under the title of "Ephémérides Météorologiques."

His many investigations made with electrical machines are embraced in the last-named publication and are also alluded to in his "Marées Aériennes," etc., which appeared in Brussels during the year 1792.

References.—"Biog. Générale," Tome XXXIII. p. 231; Larousse, "Dict. Universel," Tome X. p. 1085; *Phil. Mag.*, Vol. IV. p. 337; "Comm. Ac. Theod. Pal.," 1790, Vol. VI. p. 82.

A.D. 1787.—Bennet (Rev. Abraham), F.R.S., first describes in the *Philosophical Transactions* for this year, pp. 26–32, the gold-leaf electroscope which bears his name and which is considered the most sensitive and the most important of all known instruments for detecting the presence of electricity. It consists of a glass cylinder which is covered with a projecting brass cap, made flat in order to receive upon it whatever article or substance is to be electrified, and having an opening for the insertion of wires and of a metallic point to collect the electricity of the atmosphere. The interior of the cap holds a tube which carries two strips of gold leaf in lieu of the customary wires or threads, and upon two opposite sides of the interior of the cylinder are pasted two pieces of tinfoil directly facing the gold-leaf strips. The cap is turned around until the strips hang parallel to the pieces of tinfoil, so that any electricity present will cause the strips to diverge and make them strike the tinfoil, which will carry the electricity through the support of the cylinder to the ground.

This electroscope, says Wilkinson, possesses great sensibility, and through the movable coatings introduced by Mr. Pepys, very small portions of electricity are discernible. Another very excellent electroscope is formed with either extremely fine silver thread, prepared after the manner of Mr. Read, or with the minutest thread found in a bundle of very fine flax, having a little isinglass glue applied gently over it with the finger and thumb.

Of the numerous observations made by Bennet, the following interesting extract relative to the phenomenon of evaporation is

taken from the *Philosophical Transactions* for the year 1787. "If a metal cup with a red hot coal in it be placed upon the cap of a gold leaf electroscope, a spoonful of water thrown in electrifies the cup resinously; and if a bent wire be placed in the cup with a piece of paper fastened to it to increase its surface, the vitreous electricity of the ascending column of vapour may be seen by introducing the paper into it. The experiments on the evaporation of water may be tried with more ease and certainty of success by heating the small end of a tobacco pipe and pouring water into the head, which, running down to the heated part, is suddenly expanded, and will show its electricity when projected upon the cap of the electrometer more sensibly than any other way that I have tried. If the pipe be fixed in a cloven stick and placed in the cup of one electrometer while the steam is projected upon another, it produces both electricities at once."

Some of Mr. Bennet's experiments with the electroscope on the electricity of sifted powders, upon the electricity of the atmosphere, etc., are recorded at pp. 564 and 566 of the "Britannica," Vol. VIII, and at p. 56 of "Library of Useful Knowledge."

Mr. Bennet also invented the *electrical doubler*, designed to increase small quantities of electricity by continually doubling them until visible in sparks or until the common electrometer indicates their presence and quality (*Phil. Trans.* for 1787, p. 288). It consists of three plates of brass, illustrated and explained at Fig. 9, p. 20, Vol. I of Prescott's "Electricity and the Electric Telegraph," 1885 edition, wherein it is stated that in forty seconds the electricity can thus, by continual duplication, be augmented five hundred thousand times. (See, for doublers, C. B. Désormes and J. N. P. Hachette, in *Annales de Chimie*, Vol. XLIX for 1804; J. Read (*Phil. Trans.* for 1794, p. 266); Sir Francis Ronalds (Edin. "Phil. Journal," Vol. IX. pp. 323–325).)

At p. 105 of his "Rudim. Magnetism," Snow Harris mentions the fact that, in some of his experiments, Mr. Bennet employed a magnetic needle suspended by filaments of a spider's web as a magnetometer. In this connection, it may be said that, in the *Philosophical Transactions* for 1792, the assertion is made that a fine and weakly magnetic steel wire suspended from a spider's thread of three inches in length will admit of being twisted around eighteen thousand times and yet continue to point accurately in the meridian, so little is the thread sensible of torsion (Young's "Course of Lectures," 1807, Vol. II. p. 445). The use of the spider's line had, during the year 1775, been recommended as a substitute for wires by Gregorio Fontana, who, it is said, obtained threads as fine as the eight-thousandth part of a line. In a lecture delivered

at Boston, Mass., during the year 1884, Prof. Wood alluded to spiders' threads estimated to be one two-millionths of a hair in thickness.

References.—Bennet, "New Experiments on Electricity," etc., Derby, 1789, and "A New Suspension of the Magnetic Needle," etc., London, 1792; Introduction to "Electrical Researches," by Lord Henry Cavendish; *Sc. Am. Supplement*, No. 647, pp. 10, 327; Noad, "Manual," p. 27; Cavallo, "Nat. Phil.," 1825, Vol. II. pp. 199, 216; *Phil. Trans.*, Vol. LXXVII. pp. 26–31, 32–34, 288–296; also the abridgments by Hutton, Vol. XVI. pp. 173, 176, 282 and Vol. XVII. p. 142; *Sc. American*, Vol. LI. p. 19; *Annales de Chimie*, Vol. XLIX. p. 45; Ezekiel Walker, *Phil. Mag.* for 1813, Vol. XLI. p. 415 and Vol. XLII. pp. 161, 215, 217, 371, 476, 485; also Vol. XLIII. p. 364.

A.D. 1788.—Barthélémy (Jean Jacques), who, after completing his studies in a French seminary of Jesuits, succeeded Gros de Boze as keeper of the king's cabinet of medals, publishes in four volumes, at Paris, the first edition of his "Voyage du Jeune Anacharsis." In this well-known work, begun by him in 1757, and translated into English under the title "Travels of Anacharsis the Younger in Greece," Barthélémy alludes to the possibility of telegraphing by means of clocks (*pendules*, not *horloges*), having hands similarly magnetized in conjunction with artificial magnets. These were "presumed to be so far improved that they could convey their directive power to a distance, thus, by the sympathetic movements of the hands or needles in connection with a dial alphabet, communications between distant friends could be carried on."

Writing to Mme. du Deffand in 1772, he observes:

"It is said that with two timepieces the hands of which are magnetic, it is enough to move one of these hands to make the other take the same direction, so that by causing one to strike twelve the other will strike the same hour. Let us suppose that artificial magnets were improved to the point that their virtue could communicate itself from here to Paris; you have one of these timepieces, we another of them; instead of hours we find the letters of the alphabet on the dial. Every day at a certain hour we turn the hand, and M. Wiard [Mme. du Deffand's secretary] puts together the letters and reads. . . . This idea pleases me immensely. It would soon be corrupted by applying it to spying in armies and in politics, but it would be very agreeable in commerce and in friendship."

References.—"Correspondance inédite de Mad. Du Deffand," Vol. II. p. 99; letter of J. MacGregor in *Journal Society of Arts*, May 20, 1859, pp. 472, 473.

A.D. 1789.—Adriaan Paets Van Troostwÿk and Jean Rodolphe Deimann, Dutch chemists, associated for the purpose of scientific research, complete the experiments of Lord Cavendish and announce,

in the *Journal de Physique*, their discovery of the decomposition of water through the electric spark, which latter is conveyed by means of very fine gold wires. As is now well known, water is by this means resolved into its two elements of oxygen and hydrogen, both of which assume their gaseous form.

The electric machine they employed was a very powerful double-plate one, of the Teylerian mode of construction, causing the Leyden jar to discharge itself twenty-five times in fifteen revolutions.

REFERENCES.—" Mém. de la Soc. de Phys. Exp. Rotterdam," Tome VIII; *Journal de Physique*, Vol. XXXIII; Noad, " Manual," p. 161; " Encyl. Brit.," Vol. VIII, 1855, pp. 530, 565; " Biog. Universelle," Vol. X. p. 282; De La Rive, " Electricity," Vol. II. p. 443; Wm. Henry, " Elements of Experimental Chemistry," London, 1823, Vol. I. pp. 251, 252; Delaunay's " Manuel," etc., 1809, pp. 180–183; " Verhandl. van het Genootsch te Rotterdam " (" Mém. de la Soc. de Phys. Exp. de Rotterdam ") Vol. VIII; Poggendorff, Vol. I. p. 1555; Dove, p. 243; G. Carradori (Brugnatelli's *Annali di chimica*, Vol. I. p. 1); John Cuthbertson, " Beschreibung einer Elekt. . . ." Leipzig, 1790.

A.D. 1790.—Reveroni—Saint-Cyr (Jacques Antoine, Baron de), French Colonel and author, best known by his very interesting work, " Mécanismes de la Guerre," proposes an electric telegraph for the purpose of announcing the drawings of lottery numbers; no satisfactory information as to its construction, however, appears obtainable.

REFERENCES.—Fahie, " History," etc., London, 1884, p. 96; Etenaud, " La Télégraphie Electrique," 1872, Vol. I. p. 27; *Sc. Am. Supp.*, No. 384, pp. 6, 126.

A.D. 1790.—Mr. Downie, master of his Majesty's ship " Glory," makes a report on local attraction wherein he observes " that in all latitudes, at any distance from the magnetic equator, the upper ends of iron bolts acquire an opposite polarity to that of the latitude," an observation, Harris remarks, which accords with Marcel's experiment (at A.D. 1702).

" I am convinced," says Mr. Downie, " that the quantity and vicinity of iron, in most ships, has an effect in attracting the needle; for it is found by experience that the needle will not always point in the same direction when placed in different parts of a ship; also, it is very easily found that two ships, steering the same course by their respective compasses, will not go exactly parallel to each other; yet when their compasses are on board the same ship they will agree exactly."

REFERENCES.—William Walker, " The Magnetism of Ships," London, 1853, p. 20; J. Farrar, " Elements," p. 376; Harris, " Rudim. Magn.," 1852, Part III. p. 161.

A.D. 1790.—Tralles (Johann Georg), a German scientist, is the first to make known the negative electricity of cascades. This he communicates through his "Uber d. Elektricität d. Staubbachs," published at Leipzig.

In the Report on Atmospheric Electricity of Francis J. F. Duprez, translated from the Memoirs of the Royal Academy of Brussels by Dr. L. D. Gale, we read that one day while in the Alps, opposite the cascade of Staubbach, near Lauterbrunnen, Tralles "presented his atmospheric electrometer, not armed with the metallic wire, to the fine spray which resulted from the dispersion of the water. He immediately obtained very distinct signs of negative electricity. The same effect was exhibited at the cascade of Reichenbach. Volta, a short time after, verified the correctness of this observation, not only above the great cascades, but also wherever a fall of water existed, however small, provided the intervention of the wind caused the dispersion of the drops. The electricity always appeared to him, as it did to Tralles, negative. Schübler repeated the same experiments in his journey to the Alps in 1813. He observed farther, that this negative electricity was very strong, since it became perceptible at a distance of 300 feet from the cascade of Reichenbach; and at a distance of 100 feet his electrometer indicated 400 and even 500 degrees. . . . Tralles attributed it at first to the friction of the minute drops of water against the air; but soon after he thought, with Volta, that the cause was to be found in the evaporation which the same minute drops experience in falling. . . ."

The Italian physicist, Giuseppe Belli, who published at Milan, during 1836, "Sulla Elettricità negativa delle cascate," entertains an opinion contrary to that advanced by M. Becquerel, and believes "that the electrical phenomenon of the water of cascades is owing to the development of electricity by the induction which the positive electricity of the atmosphere exercises on the water. The water, he says, is by induction in the negative state, when the atmosphere is, as it is ordinarily, charged with positive electricity. At the moment when this water divides into thousands of minute drops, it cannot fail to carry the electricity with which the electrical induction of the atmosphere has impregnated it to all bodies which it meets."

References.—"Œuvres de Volta," Vol. II. p. 239; Franz Samuel Wilde, "Expériences sur l'électricité des cascades" ("Mémoires de Lausanne," Vol. III, "Histoire," p. 13, 1790); "Bibliographie Universelle," N. S., 1836, Vol. VI. p. 148; Houzeau et Lancaster, "Bibl. Générale," Vol. II. p. 265; "Biblio. Ital.," LXXXIII. p. 32; Schweigger, *Journal f. Chemie u. Physik,* Vol. IX. p. 358; Tralles, "Beyträge zur Lehre von der Electricität"; L. W. Gilbert's *Annalen der Physik und Chemie,* Vol. XXVIII for 1808; F. A. C. Gren's *Journal der Physik,*

Vol. I. for 1790; Humboldt, "Cosmos," London, 1849, Vol. I. p. 344, and the reference to Gay-Lussac in *Ann. de chimie et de physique*, Vol. VIII. p. 167.

A.D. 1790.—Eandi (Giuseppe Antonio Francesco Geronimo), an able physicist, native of Saluces (1735–1799), reads, May 10, before the Academy of Sciences of Turin, a Memoir upon Electricity *in vacuo* which is printed in the Collections of that Institution. He studied for the priesthood and entered the Normal College of Turin, where he followed protracted courses of literature under Bartoli and of natural philosophy under Beccaria, becoming the assistant of the latter, whom he finally replaced from 1776 to 1781. He afterward became Professor of Natural Philosophy at the College of Fine Arts, where he gave particular attention to electrical studies, and published several papers on that science, as well as upon natural philosophy generally.

He bequeathed all his possessions to his nephew Vassalli, upon condition of the latter's taking the name of Eandi.

Besides the above, he wrote: "Memorie istorische," etc., or "Historical Memoir upon the Studies of Father Beccaria," Turin, 1783, which is dedicated to Count Balbi and gives the new theories of electricity, also an "Essay upon the Errors of Several Physicists in Regard to Electricity," Turin, 1788.

References.—"Notice sur la vie. . . . d' Eandi par Vassalli-Eandi," Turin, 1804; "Biographie Générale," Vol. XV. p. 589; Larousse, "Dict. Universel," Vol. VII. p. 5; the Turin Academy Memoirs for the years 1802–1804; Eandi e Vassalli-Eandi, "Physicæ Experimentalis," etc., Turin, 1793–1794.

A.D. 1790.—Vassalli-Eandi (Antonio Maria), Italian savant (1761–1825), nephew of G. A. F. G. Eandi, who was, like his uncle, a pupil of Beccaria, publishes his views concerning the electricity of bodies and regarding other investigations, as well as a report upon experiments relative to the electricity of water and of ice, which appear respectively in L. V. Brugnatelli's *Annali di Chimica*, Vol. I. p. 53, in the "Bibl. Fis. d'Europa," Vol. XVII. p. 144, and in the third volume of "Mem. della Soc. Italiana."

He was one of the most prolific of Italian writers, his more important essays, which number 160, being written in Italian, Latin and French, and covering almost every leading branch of physical science. One of his biographers tells us, *Il a embrassé, pour ainsi dire, l'ensemble des connaissances humaines*, and that he is one of whom his country may justly be proud.

In his investigations concerning aerolites, which appeared in 1786 ("Memoria . . . sopra . . . bolidi in generale"), he explains

the movements of those bodies much more satisfactorily than had previously been done by any scientist. Essays published by him during the same year, as well as in 1789 and 1791, treat of the effect of electricity upon vegetables; then follow his papers relative to Bertholon's "Electricité des Météores," to Haüy's theories and to the meteorological observations of Senebier, De Saussure, Toaldo and Monge, up to 1792, when Vassalli was made Professor of Natural Philosophy at the Turin University. He had also in the meantime carefully looked into the scientific knowledge possessed by the ancients, and was led to believe, as shown in his "Conghietture sopra l'arte," etc., that they had the means of attracting and directing thunder and lightning. The latter fact has been alluded to in this "Bibliographical History," under the B.C. 600 entry. (See J. Bouillet, "De l'état des connaissances," etc., Saint Etienne, 1862.)

He was after this made perpetual secretary of the Royal Academy of Sciences of Turin, then became Director of the Museum of Natural History, as well as of the Observatory situated in the last-named city, which position he held at the time of his death.

His other essays treat more particularly of animal electricity, the electricity of fishes, the effects of electricity upon recently decapitated bodies, the application of electricity and of galvanism to medicine, and cover very extended observations on meteorology. He was the editor of both the "Memoirs of the Academy of Sciences of Turin, from 1792 to 1809," and of the "Annals of the Turin Observatory, from 1809 to 1818" (Larousse, "Dictionnaire Universel," Vol. XV. p. 801); was likewise editor of the "Bibliothèque Italienne," in conjunction with Giulio Gioberti and Francesco Rossi, and is said to have devised an electrometer superior to that of Volta.

References.—Vassalli-Eandi, Giulio (or Julio) e Rossi, "Rapport présenté," etc., Turin, 1802, or "Transunto del Rapporto," etc., Milano, 1803 ("Opusc. Scelti," Vol. XXII. p. 51), translated into English, London, 1803 (*Phil. Mag.*, Vol. XV. p. 38); also Vassalli-Eandi, F. Rossi et V. Michelotti, "Précis de nouvelles expériences galvaniques," Turin, 1809 ("Mém. de Turin," Années, 1805–1808, p. 160). See likewise, S. Berrutti, "Elogio," etc., 1839; "Saggio sulla vita . . . Vassalli-Eandi," Torino, 1825; "Notizie biografiche . . . Vassalli Eandi" ("Mem. di Torino," Vol. XXX. p. 19); "Elogio, scritto dal Berrutti" ("Mem. of the Ital. Soc.," Vol. XXII. p. liv); *Phil. Mag.*, Vol. XV. p. 319; *Journal de Physique*, An. VII. p. 336 and Vols. XLIX, L; "Ital. Soc. Mem.," Vols. VIII. p. 516; X. p. 802; XIII. p. 85; XVII. p. 230; XIX. p. 347; "Mémoires de Turin," Vols. X–XIII; "Mem. dell' Acad. di Torino," Vols. VI, X, XXII, XXIV, XXVI, XXVII, XXIX; "Mem. della Soc. Agrar. di Torino," Vol. I; "Opuscoli Scelti," Vols. XIX. pp. 215, etc.; XXII. p. 76; "Nuova Scelta d' Opuscoli," Vol. I. p. 167; "Opuscoli Scelti di Milano," quarto, Vol. XIV; "Mem. Soc. Ital.," Vols. IV. p. 263; X. p. 733; "Biblioteca Oltramontana"; Brugnatelli's *Annali di Chimica*; "Giornale Scientifico . . .

di Torino," Vols. I, III; " Giornale Fis. Med.," Vol. II. p. 110; " Biblioteca Italiana "—" Bibliothèque Italienne," Vols. I. p. 128; II. p. 25; " Recueil périodique . . . de Sédillot," Vol. II. p. 266.

A.D. 1790-1800.—Morozzo—Morotius—(Carlo Luigi, Comte de), Italian savant, who studied mathematics under Lagrange, and was President of the Turin Academy of Sciences, publishes numerous scientific memoirs in French through the reports of the last-named institution, in one of which he is said to have described an experiment suggesting the electro-magnet.

References.—Biography in Larousse, " Dictionnaire Universel," Tome XI. p. 577, and in the " Biographie Générale," Tome XXXVI. p. 643.

A.D. 1791.—Leslie (Sir John), an able English scientist (April 1766–Nov. 1832), who, upon the death of Prof. John Playfair, was called to the Chair of Natural Philosophy in the University of Edinburgh, writes a very interesting paper entitled " Observations on Electric Theories," which is read the following year at the meeting of the Royal Society of Edinburgh, and is published at the latter place during 1824.

According to Carnevale Antonio Arella, " Storia dell' Elettricità," Alessandria, 1839, Vol. I. p. 130, Sir John Leslie is the author of quite an interesting treatise on the inefficacy of lightning conductors, and the " English Cyclopædia " (Biography), Vol. III. p. 866, gives a list of many of the numerous contributions he made to the leading publications of his day, more particularly in the " Edinburgh Philos. Transactions," the " Encyclopædia Britannica," the " Edinburgh Review," and " Nicholson's Philos. Journal." The reviewer adds, what will surprise many readers, that, although some papers by Sir John Leslie treating of physical subjects were also read before the Royal Society of London, none were ever printed in their " Philos. Transactions."

Professor John Playfair above alluded to (1748–1819), became, during 1785, Joint Professor of Mathematics with Dr. Adam Ferguson in the University of Edinburgh and, in 1805, exchanged this for the Professorship of Natural Philosophy in the same university.

References.—Macvey Napier, " Memoir of Sir John Leslie," 1838, which appeared in seventh edition of " Encycl. Britan.," Vol. XIII; " Engl. Cycl." (Biography); Rose, " New Gen. Biogr."; Hœfer, " Nouv. Biogr. Gen.," Paris, 1862, Vol. XXX. pp. 949–952 (giving full account of his works); " Encycl. Britan.," ninth edition, Edinburgh, 1882, Vol. XIV. pp. 476–477; Sidney Lee, " Dict. Nat. Biogr.," Vol. XXXIII. pp. 105–107 and Vol. XLVIII. pp. 413–414; Pierre Larousse, " Grand Dict. Univ.," Vol. X. pp. 406–407; " Caledonian Mercury," article of Prof. Napier summarized in the " Gentleman's Magazine " for 1833, Vol. I. pp. 85–86. Consult also A.D. 1751 at Adanson; "Dove," p. 256; *Philosophical Magazine*, Vols. XL and XLII.

A.D. 1791.—At p. 353, Chap. III of the first volume of Gmelin's "Handbook of Chemistry," it is stated that during 1791 James Keir (Kier) first showed, by immersing iron in a solution of nitrate of silver or fuming nitric acid, that many metals can be made to pass from their ordinary *active* state into a *passive* or electro-negative state and lose either wholly or in part their tendency to decompose acids and metallic oxides.

At pp. 167–170, Sixth Memoir, of Wm. Sturgeon's "Scientific Researches" (Bury, 1850), treating of the application of electro-chemistry to the dissolution of simple metals in fluids, reference is made to the long line of investigations carried on by both Bergman and Keir, the last named having demonstrated that iron "acquires that *altered* state by the action of nitric acid which Sir John Herschel met with in his experiments, and has called *prepared* state, and that Schönbein and others call the *peculiar* or the *inactive* state" (Noad's "Manual of Electricity," London, 1859, p. 534). The iron which is active in nitric acid was called by Keir "fresh iron," while that which became inactive he designated as "altered iron" (Sturgeon's "Annals of Electricity," Vol. V. p. 439).

Some remarkable phenomena in the display of which but one individual piece of metal is used, as first shown by Keir, remain, Sturgeon says, "without even an attempt at explanation by any of the philosophers under whose notice they have appeared." Sir John Herschel pronounces them as of an "extraordinary character"; Prof. Andrews, after giving some very satisfactory explanations of several phenomena, acknowledges that he "can offer no explanation of most of the particular facts which have been described," and Professor Schöenbein "has not made public any conclusive explanation of them whatever" (*Phil. Mag.* for October 1837, p. 333, and for April 1838, p. 311).

This same James Keir, called by Watt "a mighty chemist" (1735–1820), has strangely by some been confounded with Robert Kerr, also a Scotchman, who was an able scientific writer and lived at about the same period (1755–1813). Kerr made valuable translations from Lavoisier and Linnæus which, during 1805, won for him a fellowship in the Edinburgh Royal Society. (Consult Sidney Lee, "Dict. of Nat. Biogr.," London, 1892, Vol. XXI. p. 64, also the references therein given; and the article "Faraday" in the "Encycl. Britan.," ninth edition, Edinburgh, 1879, Vol. IX. p. 30.)

References.—Mrs. Amelia Moillet, "Sketch of the Life of James Keir," 1859; Sidney Lee, "Dict. of Nat. Biog.," London, 1892, Vol. XXX. pp. 313–314; *Annales de Chimie* for October 1837; *Phil. Trans.* for 1790, p. 353, as well as Hutton's abridgment of the same, Vol. XVI. p. 694; Sturgeon's "Annals of Electricity," Vol. V. p. 427; Gmelin's Chemistry, pp. 367, 370.

A.D. 1791.—Shaw (George), English naturalist, who became a Fellow of the Royal Society during the year 1789, communicates to the latter body a paper on the *Scolopendra electrica* and *Scolopendra subterranea* ("Linn. Soc. Trans.," I. pp. 103–111). This was afterward translated into Italian and appeared in Vol. IX. p. 26, of Brugnatelli's *Annali di Chimica*. Mr. James Wilson, F.R.S.E., in his "Encycl. Brit." article on *Myriapoda*, alludes to the *Scolopendra electrica* as figured by Frisch and described by Geoffroy in his "Histoire des Insectes," Vol. II. p. 676, n. 5. Shaw also treats of the *Trichiurus Indicus*, which Sir David Brewster believes to be the same as the *trichiurus electricus*, known to inhabit the Indian Seas and to have the power of giving electric shocks.

Five years before the above date (1786), the *Phil. Trans.* contained (p. 382) the description of the *tetraodon electricus*, which Lieutenant William Paterson discovered in the cavities of the coral rocks of one of the Canary Islands and which he found to possess the properties of other electrical fishes. (See Hutton's abridgments, Vol. XVI. p. 134.)

REFERENCES.—"Biographie Générale," Vol. XLIII. p. 922; "Gentleman's Magazine," Vol. LXXXIII; Poggendorff, Vol. II. p. 918; "Cat. Royal Society Sc. Papers," Vol. V. p. 674; Dr. Thomas Young, "Course of Lectures," London, 1807, Vol. II. p. 436, for the *Trichiurus Indicus* . . .

Having thus far called attention to the most important varieties of the electrical fishes, notably at the articles Adanson (A.D. 1751), Bancroft (A.D. 1769), Walsh, also Hunter (A.D. 1773), the following original list of additional references will prove interesting:

Raia Torpedo.—Stephani Lorenzini, "Osservazioni . . ." Firenze, 1678; R. A. F. de Réaumur, "Des Effets . . ." Paris, 1714; Templeman, in "Nouvelliste," 1759; Ingen-housz (*Phil. Trans.*, 1775); Cavendish (*Phil. Trans.*, 1776, Vol. LXI. p. 584, Vol. LXVI. p. 196, also Hutton's abridgments, Vol. II. p. 485; Vol. XIII. p. 223; Vol. XIV. p. 23); F. Soave ("Scelta di Opuscoli," Vol. XV), Milano, 1776; J. A. Garn, "De Torpedine . . ." Witteb., 1778; R. M. de Termeyer (Raccolta Ferr. di Op. Sc. . . . Vol. VIII), Venice, 1781; L. Spallanzani ("Goth. Mag.," V. i. 41; "Opusc. Scelti," VI. 73), Milano, 1783; Girardi and Walter ("Mem. Soc. Ital.," III. 553), Verona, 1786; W. Bryant ("Tr. Amer. Phil. Soc.," II. 166, O. S.), Philad., 1786; J. W. Linck, "De Raja Torpedine," Lips., 1788; Vassalli-Eandi (*Journal de Physique*, Vol. XLIX. p. 69); Geoffroy Saint-Hilaire ("Annal. du Mus.," An. XI. Vol. I., No. 5, and *Phil. Mag.*, Vol. XV. p. 126), 1803; J. F. M. Olfers, "Die Gattung Torpedo . . ." Berlin, 1831; Linari-Santi in "Bibl. Univ.," Ser. II., Geneva, 1837–1838, and in "Bibl. Ital.," Vol. XCII. p. 258, Milan, 1839; C. Matteucci, "Recherches . . ." Genève, 1837 ("Royal Soc. Catalogue of Sc. Papers," Vol. IV. pp. 285–293); also Delle Chiaje, "On the Organs . . ." and P. Savi, "Etudes . . ." Paris, 1844; G. Pianciani ("Mem. Soc. Ital.," XXII. 7); F. Zantedeschi ("Bull. Acad. Brux.," VIII. 1841); A. Fusinieri ("Ann. del Reg. Lomb.-Veneto," VIII. 239), Padova, 1838; A. F. J. C. Mayer, "Spicilegium . . ." Bonnæ, 1843; L. Calamai, "Osservazioni . . ." 1845; C. Robin, "Recherches . . ." Paris, 1847; Krünitz, "Abhandl.," XVII; *Nicholson's*

Journal, Vol. I. p. 355; Rozier, IV. p. 205; "Acad. Brux.," 111; "Phil. Hist. and Mem. of the Roy. Acad. of Sc. Paris," 1742, Vol. V. pp. 58–73; John Ewing, at A.D. 1795; Dr. Godef. Will. Schilling (in original Latin, also the French translation), "Biblioth. Britannique," Vol. XL. pp. 263–272; Dr. Jan Ingen-housz in *Phil. Tr.* Vol. LXV. p. 1; Vol. LXVIII. pp. 1022, 1027; Vol. LXIX. pp. 537, 661; also Hutton's abridgments, Vol. XIII. p. 575; Vol. XIV. pp. 462, 463, 589, 598; "Journal des Sçavans," Vol. LXXVIII. for January–April, 1726, p. 58; "The System of Natural History, written by M. De. Buffon," Edinburgh, 1800, Vol. II. pp. 24–25.

M. R. A. F. De Réaumur, mentioned above, has communicated the results of his investigations relative to the *torpedo* in "Mém. de Paris" for 1714, following it up more particularly with another article in the issue for year 1723 on magnetization, which is also alluded to in "Journal des Sçavans," Vol. LXXXII. for 1727, p. 4.

Silurus Electricus.—Ranzi, on the discovery of the discharge of this animal; P. Forskal "Beobachtungen . . ." 1775; F. Pacini, "Sopra l' Organo . . ." Bologna, 1846; Abd-Allatif, Relation de l'Egypte, p. 167, quoted at p. 250; Note XI. vol. i. of Libri's "Hist. des Mathém."; C. Maspero, "The Dawn of Civilization," New York, 1894, p. 36, wherein it is said that the silurus was the *nârû* of the ancient Egyptians, as described by Isidore Geoffroy de St. Hilaire in his "Histoire Naturelle des Poissons du Nil."

Gymnotus Electricus.—T. Richer, "Observations . . ." Paris, 1679 ("Hist. et Mém. de l'Acad. Roy. des Sciences," Vols. I. p. 116; VII. i. pt. 2, p. 92); "Edinburgh Review," Vol. XVI. pp. 249–250; John Ewing at A.D. 1795; P. Sue, aîné "Histoire du Galvanisme," Paris, An. X, 1802, Vol. II. pp. 94–97; A. Van Berkel, "Reise nach Rio . . ." Memming, 1789, for the observations made in 1680–1689; J. B. Duhamel ("Hist. Acad. Sc.," 168); J. N. Allamand, "On the Surinam Eel . . . by S'Gravesande," Haarlem, 1757; Gronov-Gronovius ("Acta Helvetica . . ." IV. 26, Basle, 1760; *Phil. Trans.*, Vol. LXV. part i. p. 94, 102, and part. ii. p. 395); P. V. Musschenbroek ("Hist. et Méms. de l'Acad. des Sc.," 1760); G. W. Schilling, "Diatribe de Morbo . . ." 1770, treating of the torpedo as well as of the *magnetism* of the Gymnotus (which latter was observed by him in 1764, and is alluded to besides by Jan Ingen-housz in his "Nouv. Exper.," Paris, 1785); "Mem. of Berlin Acad. of Sc.," Bonnefoy, "De l'app. de l'élect . . ." 1782–1783, p. 48; Ferdinando Elice, "Saggio sull' Elettricità," p. 26; H. Williamson, Alexander Garden and John Hunter in the *Phil. Trans.* for 1775, p. 94, 102, 105, 395, and in Hutton's abridgments, Vol. XIII. pp. 597–600; R. M. de Termeyer ("Opus. Scelti," IV. 324, for 1781); H. C. Flagg ("Trans. Amer. Phil. Soc.," O. S., Vol. II. p. 170); Samuel Fahlberg, "Beskrifning ofver elektriska alen Gymnotus electricus," Stockholm, 1801; (See Fahlberg at A.D. 1769, and in "Vet Acad. Nyr. Handl."; Gilbert, *Annalen*, XIV. p. 416); Humboldt, "Observations . . . anguille elect . . ." Paris, 1806; "Versuche . . . elec. fische," Jena, 1806; also in the *Annales de Chimie et de Physique*, Vol. XI for 1819, and at p. 256 of the "Harmonies of Nature," by Dr. G. Hartwig, London, 1866, will be found a picture showing mode of capture of the Electric Eel; F. S. Guisan, "De Gymnoto . . ." Tübingen, 1819, Carl Palmstedt ("Skand. Naturf. motets Forhand," 1842); H. Letheby ("Proceedings London El. Soc.," Aug. 16, 1842, and June 17, 1843); M. Vanderlot's work, alluded to by Humboldt at p. 88 of his "Voyage . . ."; F. Steindachner, "Die Gymnotidie . . ." Wien, 1868.

Consult likewise, for reputed magnetic powers of the *echeneis*, or sucking-fish, Gaudentius Merula, "Memorabilium," 1556, p. 209; Fracastorio, "De Sympathia," lib. 1, cap. 8; W. Charleton, "Physiologia," 1654, p. 375; Cornelius Gemma, "De Naturæ Divinis," 1575, lib. 1, cap. 7, p. 123; and, for electrical fishes generally, Rozier, Intr., II. p. 432; Bloch, "Naturgeschichte . . ." Berlin, 1786; A. De

la Rive, "Traité de l'électricité," Paris, 1858, Vol. III. pp. 61–82; Rozier, Vol. XXVII. pp. 139–143; "Works of Michael de Montaigne," by W. Hazlitt, New York, 1872, Vol. II. pp. 158–159; R. J. Haüy, "Traité de Physique," p. 41; Geoffroy Saint-Hilare (*Journal de Physique*, LVI. 242; *Phil. Mag.* XV. 126–136, 261; "B. Soc. Phil." N. 70; Gilbert, *Annalen*, XIV. 397; "Ann. du Mus." for 1803); M. Schultze, "Zur Kentniss . . . elect . . . fische," Halle, 1858 and 1859; Jobert (de Lamballe) "Des Appareils . . ." Paris, 1858; W. Keferstein and D. Kupffer (Henle u. Pfeuffer's "Zeitschr. f. rat. Med. Newe Folgc," III. 1858) and Keferstein's "Beitrag . . . elekt. fische," Göttingen, 1859; "Annual of Sc. Discovery" for 1863, giving, at pp. 115–116, the views of Sir John Herschel, of Charles Robin and of M. Moreau on the electrical organs of fishes.

A.D. 1792.—Berlinghieri (Francesco Vacca, and not Vacca Leopold nor Andrea Vacca), Italian surgeon and anatomical writer, communicates to M. De La Méthérie the result of the extensive experiments made by him in concert with M. Pignotti and his brother. After describing his investigations with frogs, he remarks that the same movements and contractions can be produced on animals with hot blood, but that the latter require a peculiar process. He says that after having dissected the crural or any other considerable nerve, and cut it at a certain height to separate it from its superior part, it should have a piece of tinfoil wrapped around its summit, and the communication should be made in the usual way by touching the coating with one of the extremities of the exciting arc and the muscles in which the nerve is distributed with the other extremity.

Many other investigations of Berlinghieri were, later on, communicated to the Société Philomathique, by whom they were successfully renewed, and, during the year 1810, a translation of his paper on the method of imparting magnetism to a bar of iron without a magnet appeared at p. 157, Vol. XXXV. of the *Philosophical Magazine.*

References.—Rozier, XL. p. 133, and XLI. p. 314; "Giorn. di Med. Prac. di Brera," IX. pp. 171–298; L. B. Phillips, "Dict. of Biog. Ref.," 1871, p. 137; Tipaldo, "Biografia . . ." 1834.

A.D. 1792.—Lalande (Joseph Jérome le Français de), a distinguished scientist, and, doubtless, the best known of all French astronomers, who had previously communicated (1761) observations on the loadstone to the "Mémoires de Paris," and had likewise written upon meteoric displays (1771), addresses to the *Journal des Sçavans* of Nov. 1792 a treatise entitled "Une Notice sur la découverte du Galvanisme," justifying his claim to being the first introducer of galvanism into France, which he had before made through the columns of the *Journal de Paris* of the 17 Pluviôse, An. VII.

REFERENCES.—Lalande, "Abrégé de l'Astronomie," pp. 101, etc.; "Biog. Générale," Vol. XXVIII. p. 948; "Biog. Universelle," Vol. XXII. pp. 603–613; Ninth "Enc. Britannica," Vol. XIV. p. 225; P. Sue, aîné, "Hist. du Galv.," Paris, An. X (1802), Vol. I. p. 1.

A.D. 1792.—Chappe (Claude), a French mechanician (1763–1805), introduces the *sémaphore*, which he at first called a *tachygraphe*, from two Greek words meaning to write fast, but to which M. Miot, chief of one of the divisions of the War Department, gave the name of telegraph during the year 1793. Chappe had not long before devised a contrivance somewhat like that alluded to by Barthélémy (A.D. 1788), but it was not apparently brought into use.

His *sémaphore* consisted of a vertical wooden pillar 15 feet or 16 feet high, bearing a transverse beam 11 feet or 12 feet long, which turned upon its centre and held at each extremity pivoted arms so worked by cords or levers as to admit of 256 distinct signals. The semaphores were placed upon high towers, about four miles apart, on level ground, and even as much as ten miles apart upon intervening elevations. This system of signals was presented by Chappe to the Assemblée Législative, and was originally erected during the month of August 1794 upon stations between Paris and Lille (Lisle), a distance of about 148 miles. One of the first sentences conveyed between the two places by the Committee of Public Safety consumed 13 minutes and 40 seconds, but it was not long before dispatches could be conveyed in two minutes' time, and it was through Chappe's apparatus that the news of the recapture of the city of Condé was conveyed to the Assembly shortly after the entry of the troops of the Republic.

It is not now believed that Claude Chappe was acquainted with the devices of either Robert Hooke (at A.D. 1684) or of Guillaume Amontons (at A.D. 1704), as was at the time claimed by many of his jealous contemporaries. No doubt exists that he is justly entitled to the credit of having, with the assistance of other members of his family, developed an entirely new system of signals as well as the mechanism by which they were operated. The histories of telegraphy written by I. U. J. Chappe (Paris, 1824; Le Mans, 1840) review Claude Chappe's investigations and the difficulties he encountered, besides making reference to the false magnetic telegraphs of A. T. Paracelsus (A.D. 1490–1541), William Maxwell (A.D. 1679), and F. Santanelli ("Philosophiæ reconditæ . . ." Coloniæ, 1723) alluded to in the "Dictionnaire des Sciences Médicales."

Claude Chappe's uncle, L'Abbé Jean Chappe d'Auteroche (1722–1769), French astronomer, who succeeded N. L. de la Caille at the Paris Observatory as assistant to Cassini de Thury and edited a translation of the works of Dr. Halley, is the author of several memoirs upon the declination and inclination and upon

lightning, meteors, etc., alluded to in J. B. J. Delambre's "Hist. de l'Astron. au 18e siècle," in J. C. Poggendorff's "Biog.-Liter. Hand.," Vol. I. p. 420, and in the "Mém. de Paris," 1767, *Mém.* p. 344.

REFERENCES.—English Encyl., "Arts and Sciences," Vol. VIII. p. 65; "Johnson's Encyl.," Vol. IV. p. 757; "Penny Ency.," Vol. XXIV. p. 146; Shaffner, "Manual," pp. 27, 45 and 48; "Le Cosmos," Paris, Feb. 4, 1905, p. 128; Nicholson's "Journ. of Nat. Phil.," Vol. VIII. p. 164, note; *Sc. American Supplement,* No. 475, p. 7579; "Emporium of Arts and Sciences," Vol. I. p. 292; Rozier, XXXIV. p. 370, and XL. p. 329; "Bull. des Sc. de la Société Philomathique," March 1793, No. 21, for an account of the experiments of Galvani and of Valli repeated for the Society by C. Chappe, M. Robillard and A. F. de Silvestre.

A.D. 1792.—Valli (Eusebius), Italian physician of Pisa, corresponding member of the Royal Academy of Sciences at Turin, publishes his "Experiments on Animal Electricity," the results of which were communicated to the French Academy of Sciences and found to be of such great importance that a committee composed of Messrs. Le Roy, Vicq d'Azyr, Coulomb and Fourcroy, was directed to repeat them. The most important were repeated in Fourcroy's laboratory on the 12th of July 1792.

Valli was the first to demonstrate that when an arc of two metals, plumber's lead and silver, is employed upon an animal, the most violent contractions are produced while the lead is applied to the nerves and the silver to the muscles. He also showed that of all metals, zinc, when applied to the nerves, has the most remarkable power of exciting contractions; and he found that when a frog had lost its sensibility to the passage of a current, it regained it by repose.

These experiments were also repeated before the French Royal Society of Medicine. M. Mauduyt, who was present, deduced from the results obtained by Valli that the metals were charged with a different quantity of the electric fluid, in so much that when they were brought in contact with each other a discharge ensued. And, secondly, that the animal body, by which the electric fluid is rendered perceptible, is a more delicate electrometer than any one heretofore discovered.

Many new and very interesting investigations were afterward made by Valli upon different animals, the results of which were given to the public through the columns of the *Journal de Physique* as shown below. These embrace thirteen experiments upon animals rendered insensible by means of opium and powdered tobacco, showing electricity to be independent of their vitality, as well as others to show that the electric fluid is necessary to man and animals. He fully established the identity of the nervous and the electric

fluids, and proved that the convulsions took place by merely bringing the muscles themselves into contact with the nerves, without the intervention of any metal whatever. In answer to the inquiry of M. Vicq d'Azyr, member of the late French Academy of Sciences, he supported by nineteen experiments the assertion that however the blood vessels may be, as they assuredly are, conductors of electricity, the nerves alone prove capable of exciting muscular movements in consequence of the mode in which they are disposed.

References.—Brugnatelli, *Annali di Chimica*, Vol. VII. pp. 40, 213, 228 (and pp. 138, 159, 186, 208 for Caldani); also the "Giornale Fis. Med. di Brugnatelli," Vol. I. p. 264; Sue, "Histoire du Galvanisme," Paris, An. X–1802, Vol. I. p. 45; "Société Philomathique," Vol. I. pp. 27, 31, 43; *Journal de Physique*, Vol. XLI. pp. 66, 72, 185, 189, 193, 197, 200, 435; Vol. XLII. pp. 74, 238, the last named containing the "Lettre sur l'Electricité Animale" ("De animalis electricæ theoriæ . . ." Mutinæ, 1792) sent by Valli to MM. De La Méthérie and Desgenettes; Report of MM. Chappe, Robillard and Silvestre on Valli's and Galvani's experiments ("Soc. Phil." for March 1793, No. 21); Report of Messrs. Le Roy, Vicq d'Azyr and Coulomb in "Médecine éclairée par les Sciences Physiques," Tome IV. p. 66; "Epitome of Electricity and Magnetism," Philad., 1809, p. 133; "Versuche . . . animal, electricität" of Karl Friedrich Kielmayer (Kielmaier) of the Tübingen University (Poggendorff, Vol. I. p. 1253; F. A. C. Gren, *Journal der Physik*, Vol. VIII for 1794); Floriano Caldani's works, 1792–1795, and those of Leopoldo Marc-Antonio Caldani, 1757–1823; Junoblowiskiana Society, 1793–1795.

A.D. 1793.—Fontana (Felice), distinguished Italian experimental philosopher and physiologist, gives in his "Lettere sopra l' Elettricità Animale," the result of further extensive investigations carried on by him to ascertain more especially all the features of galvanic irritability and the peculiar actions of the several organs in cases of death by electricity. Some of his previous observations in the same line had already been made known through his "Di Moti dell' Iride," 1765, and "Richerche filosofiche," 1775, all which led to an active correspondence in after years with the Italian Giochino Carradori, as will be seen by consulting the volumes of Luigi Valentino Brugnatelli's well-known "Giornale Fisico-Medico" (Cuvier, in "Biog. Univ.," Vol. XV. p. 8, par. 1816; "Giornale Fisico-Medico," Vol. IV. p. 116).

Fontana (Gregorio), younger brother of Felice Fontana, likewise an able natural philosopher, succeeded the celebrated Ruggiero Giuseppe Boscovich in the Chair of Higher Mathematics at the University of Padua, and is the author of "Disquisitiones physico-mathematicæ," Papiæ, 1780, as well as of many papers in the "Mem. della Soc. It. delle Scienze," wherein he gives detailed accounts of many very interesting electrical observations. Mention of Gregorio Fontana's name has already been made under Bennet, A.D. 1787.

References.—Houzeau et Lancaster, "Bibl. Gén.," Vol. I. part i. p. 334, and, for R. G. Boscovich, "The Edinburgh Encyclopædia," 1830, Vol. III. pp. 744–749.

A.D. 1793.—Aldini (Giovanni), nephew of Luigi Galvani and one of the most active members of the National Institute of Italy, who succeeded his former instructor, M. Canterzani, in the Chair of Physics at the Bologna University, established in the last-named Institution a scientific society whose open object was to combat all of Volta's works and which became very hostile to the organization already formed in the University of Pavia by Felice Fontana, Bassiano Carminati and Gioachino Carradori against the followers of Galvani. Similar societies espousing the cause of Volta were subsequently organized in England, at the suggestion of Cavallo and others, and during five years, the scientists of Europe were divided between the two discoverers, without, however, any material benefit accruing therefrom to either faction.

Aldini proved to be an indefatigable investigator, as shown by the numerous Memoirs sent by him to the publications named below, up to the month of October 1802, when he experimented before the Galvani Society of Paris. An account of these experiments is given in his "Essai théorique," etc., where, among other results, attention is called to the curious fact that contractions can be excited in a prepared frog by holding it in the hand and plunging its nerves into the interior of a wound made in the muscle of a living animal (Figuier, "Exposition," etc., Vol. IV. p. 308). His interesting investigations of the artificial piles of muscle and brain, first made by M. La Grave and shown to the French Galvani Society, are alluded to in *Nicholson's Journal*, Vol. X. p. 30, in the *Journal de Physique*, An. XI. pp. 140, 159, 233, 472, and in Sturgeon's "Scientific Researches," Bury, 1850, p. 195.

Nearly all of Aldini's experiments were successfully repeated in London at Mr. Wilson's Anatomical Theatre, where Mr. Cuthbertson assisted Prof. Aldini in arranging the apparatus, and where a student, by the name of Hutchins, furnished the anatomical preparations, but the demonstration, of all others, which attracted most attention was doubtless the one made in London on the 17th of January 1803. The murderer Forster had just been executed and, after his body lay for one hour exposed in the cold at Newgate, it was handed over to Mr. Koate, President of the London College of Surgeons, who, with Aldini, made upon it numerous important observations to ascertain the precise effects of galvanism with a voltaic column of one hundred and twenty copper and zinc couples. The extraordinary results obtained, which cannot properly be enumerated here, are to be found in the "Essai Théorique," etc.,

already alluded to. They led Aldini to believe he could, by the galvanic agency, bring back those in whom life was not totally extinct, such as in cases of the recently drowned or asphyxiated. (Consult M. Bonnejoy's method of proving death by . . . Faradization, Paris, 1866, and Georgio Anselmo, "Effets du Galvanisme . . ." Turin, 1803; S. T. Sömmering, "On the application of Galvanism to ascertain the reality of death," Ludwig scripter nevrolog., III. 23; Ure, "Exper. on the body of a criminal . . ." "Journal of Sc. and Arts," No. XII; *Phil. Mag.*, Vol. LIII. p. 56; Jean Janin de Combe Blanche, "Sur les causes," etc., Paris, 1773 (hanging); C. W. Hufeland, 1783, for the app. of Elec. in cases of asphyxia; T. Kerner, for the appʳ. of Galv. and Magn. as restoratives, Cannstadt, 1858; Wm. Henley, for electricity as a stimulant . . . drowned or . . . suffocated, "Trans. of the Humane Society," Vol. I. p. 63.)

Another of Aldini's curious experiments was the production of very powerful muscular contractions upon the heads of oxen and other animals recently decapitated, by introducing into one of the ears a wire connecting with one of the battery poles and into the nostrils or tongue a wire communicating with the other pole. Thus were the eyes made repeatedly to open and roll in their orbits while the ears would shake, the tongue move and the nostrils dilate very perceptibly (De la Rive, "A Treatise on Electricity," 1856, Vol. II. p. 489, and 1858, Vol. III. p. 588; Pepper, "Voltaic Electricity," 1869, pp. 287, 288). In the experiments which Aldini made during 1804 upon corpses, the body became violently agitated and even raised itself as if about to walk, the arms alternately rose and fell and the forearm was made to hold a weight of several pounds, while the fists clenched and beat violently the table upon which the body lay. Natural respiration was also artificially re-established and, through pressure exerted against the ribs, a lighted candle placed before the mouth was several times extinguished.

For the experiments of the eminent French physiologist and anatomist Marie François Xavier Bichat, of Vassalli-Eandi, Giulio, Rossi, Nysten, Hallé, Mezzini, Klein, Bonnet, Pajot-Laforest, Dudoyon, Berlinghieri, Fontana, Petit-Radel, Alizeau, Lamartillière, Guillotin, Nauche and others upon animals and men recently decapitated, see Bichat's "Recherches Physiologiques sur la vie et la mort," Paris, 1805; Francesco Rossi's "Rapport des expériences," etc., Turin, 1803; P. H. Nysten's "Nouvelles Expériences Galvaniques," etc., Paris, 1811, and also the latter's "Expériences faites . . . le 14 Brumaire, An. XI." (Consult likewise, J. R. P. Bardenot, "Les Recherches . . . refutées," Paris, 1824, and, for an account of Bichat consult F. R. Buisson, "Précis historique . . ."

Paris, 1802; Larousse, Vol. II. pp. 703, 704; "Biog. Univ.," Vol. XI. pp. 2–19.)

In Aldini's "Account of Galvanism," printed for Cuthell and Martin, London, 1803, it is said (p. 218) that, on the 27th of February 1803, he transmitted current through a battery of eighty silver and zinc plates from the West Mole of Calais harbour to Fort Rouge, by means of a wire supported on the masts of boats, and made it return through two hundred feet of intervening water.

References.—J. B. Van Mons' treatise on animal electricity in Tome III of the sixth year of the "Magasin Encyclopédique"; Fowler, in "Bibl. Britannica," May 1796; Giulio e Rossi ("Gior. Fis. Med. di Brugnatelli," 1793, Vol. I. p. 82); P. Sue, aîné, "Hist. du Galvanisme," Paris, An. X, 1802, Vol. I. pp. 31, 67, 73; Vol. II. p. 268; Brugnatelli, *Annali di Chimica*, Vols. XIII. p. 135; XIV. p. 174; XIX. pp. 29, 158; "Opuscoli Scelti," Vols. XVII. p. 231; XIX. p. 217; XX. p. 73; XXI. p. 412; "Mem. Soc. Ital.," Vol. XIV. p. 239; Poggendorff, Vol. I. p. 27; "Bibl. Britan.," Vol. XXII. 1803, pp. 249–266; "Galvanische und elektrische . . . Körpern," 4to, Frankfort, 1804; "Bull. des Sc. de la Soc. Philom.," No. 68; J. C. Carpue, "Bibl. Britannica," Nos. 207, 208, p. 373; *Phil. Mag.*, Vols. XIV. pp. 88, 191, 288, 364; XV. pp. 40, 93; Cassius Larcher, M. Daubancourt et M. Zanetti, ainé (*Ann. de Chimie*, Vol. XLV. p. 195); also Larcher, Daubancourt et M. de Saintiot (Précis succinct, etc., Paris, 1803); W. Sturgeon, "Scientific Researches," Bury, 1850, p. 194: M. Kilian, "Versuche über restitution . . ." Giessen, 1857; Gilbert, IV. 246; J. Tourdes ("Décade Philos." No. 3, An. X. p. 118); Francesco Rossi ("Bibl. Ital.," Vol. I. p. 106; *Phil. Mag.*, Vol. XVIII. p. 131; and in the "Mémoires de Turin"); J. J. Sue, "Recherches Physiol.," etc., 1803, p. 77; Vassalli-Eandi ("Expériences sur les décapités . . ." Turin, 1802 and "Recueil . . . de Sédillot," Vol. II. p. 266); C. H. Wilkinson, "Elements of Galvanism," etc., London, 1804, 2 Vols. *passim;* Report of MM. Chappe, Robillard and Silvestre ("Bull. des Sciences de la Soc. Philom.," No. 21 for March 1793; also *Jour. de Phys.*, Vol. XLII. p. 289); M. Payssé ("Jour. de la Soc. de Pharm.," first year, p. 100); Dr. Crichton ("Rec. Périod. de Litt. Méd. Etrangère," Tome II. p. 342); J. Louis Gauthier, "Dissertatio," etc., Hales, 1793 ("Com. de Leipzig," Tome XXXVI. p. 473); Gardiner's "Observ. on the animal œconomy"; Humboldt ("Soc. Philom.," Vol. I. p. 92); Alex. Monro's "Experiments," etc., Edin., 1793, 1794 ("Trans. Edin. Roy. Soc.," Vol. III); Felice Fontana, "Lettere . . ." 1793; Joseph Izarn, "Manuel du Galvanisme," Paris, An. XII, 1804, pp. 97, 138, 141, 160, 163, 285; Louis Figuier, "Exposition et Histoire," Vol. IV. pp. 307–308, 358, 360–363, 365, 366, 370, 371.

A.D. 1793.—Fowler (Richard), a very ingenious physician, of Salisbury, makes known in Edinburgh his "Experiments and Observations relative to the influence lately discovered by Galvani and commonly called Animal Electricity," of which a very complete review is made by Dr. G. Gregory at pp. 374–381, Vol. I of his "Economy of Nature," etc., third edition, published in London during the year 1804.

Dr. Fowler observed that the contractions in a frog are excited by making the metals touch under water even at the distance of an inch from the divided spine of the animal. He succeeded in causing the heart to contract, but could not produce the same

effect upon the stomach and intestines. He also found, as did Prof. John Robison, of Edinburgh, at the same period, that the senses of touch and smell are unaffected by the metals, but that when these are applied to the eye, or, what is better, when they are thrust up between the teeth and the lips, and then made to touch, a flash of light is rendered visible. This is the case also when the metals are placed between the gums and the upper and lower lips, as proven by the experiments of Dr. Rutherford and of Mr. George Hunter, of York. Fowler likewise observed that all pure metals prove excellent conductors of the galvanic influence and that living vegetables afford it a ready passage, but that stones and oils seem to be possessed of no conducting power whatsoever.

In conjunction with Mr. Alexander Munro, Fowler published a work on animal electricity (translated into German under the title of "Abhandlung ueber thierische elekt.," etc.), while, in the "Bibliotheca Britannica" for May 1796, mention will be found of the observations of Dr. Fowler respecting the muscular irritability excited by electricity, as well as on the reproduction of the nervous substance, on the action of poisons, on the phenomena of muscular contraction, etc. etc.

References.—"Essays and Observations," etc., Edinburgh, 1793, in Library of the Royal Institution; Gilbert Blane's paper read to the English Royal Society, of which an extract can be found in Bacher's "Medical Journal," Vol. XC. p. 127; Figuier, "Exp. et Hist. des Princip. Déc.," Vol. IV. p. 309; C. H. Wilkinson, "Elements of Galvanism," London, 1804, Chap. VI. *et passim*; eighth "Encyc. Brit.," Vol. XXI. p. 634.

A.D. 1793.—Dalton (John), LL.D., F.R.S. (1766–1844), a very able English natural philosopher and the illustrious author of the "Atomic Theory of Chemistry and of the Constitution of Mixed Gases," gives in his earliest separate publication, "Meteorological Observations and Essays," the result of many experiments upon the electricity of the atmosphere, made by him at Kendal and at Keswick during the seven years ending May 1793.

He proved, as Sir David Brewster expresses it, that the aurora exercises an irregular action on the magnetic needle, that the luminous beams of the aurora borealis are parallel to the dipping needle; that the rainbow-like arches cross the magnetic meridian at right angles; that the broad arch of the horizontal light is bisected by the magnetic meridian; and that the boundary of a limited aurora is half the circumference of a great circle crossing the magnetic meridian at right angles, the beams perpendicular to the horizon being only those on the magnetic meridian.

In the eighth "Encyclopædia Britannica" (Vol. IV. p. 246), treating of the height of polar lights, reference is made to the

extraordinary aurora borealis observed by Dalton on the 29th of March 1826, and of which a description is given in a paper read before the Royal Society, April 17, 1828 (*Phil. Mag. or Annals*, Vol. IV. p. 418; *Philosophical Transactions* for 1828, Part II; James Hoy in *Phil. Mag.*, Vol. LI. p. 422; J. Farquharson in *Phil. Trans.* for 1839, p. 267). This aurora was seen in places one hundred and seventy miles apart and covered an area of 7000 to 8000 square miles. In Vol. XIV of the same Encyclopædia will be found (p. 15), an account of another aurora observed at Kendal, February 12, 1793, while at p. 12 are given Dalton's views as to the connection between the heat and magnetism of the earth, and, at p. 66, his conclusions as to the cause of the aurora and its magnetic influence.

REFERENCES.—"Memoirs of Dalton's Life," by Dr. W. C. Henry, London, 1854; "Life and Discoveries of Dalton," in *British Quarterly Review*, No. 1; *Pharmaceutical Journal*, London, October 1841; Thomson's "History of Chemistry," Vol. II; Young's "Course of Lectures," London, 1807, Vol. I. pp. 706–709, 753, and Vol. II. pp. 466–470; Noad, "Manual," etc., London, 1859, pp. 226, 269, 534; article, "Aurora Borealis," immediately following A.D. 1683; Sir H. Davy, "Bakerian Lectures," London, 1840, pp. 322, 323, 328–330; "Dict. of Nat. Biog.," Vol. XIII. pp. 428–434, as well as the numerous references therein cited. Consult also, for theories, investigations, observations, records, etc., of the Aurora Borealis: Georg. Kruger, 1700; J. J. Scheuchzer, 1710–1712, 1728–1730; L. Feuillée, 1719; J. L. Rost, 1721; J. C. Spidberg, 1724; W. Derham, 1728, 1729–1730; F. C. Mayer—Meyer, 1726; J. F. Weidler, 1729, 1730, 1735; J. Lulolfs, 1731; M. Kelsch, 1734; F.M. Zanotti, 1737, 1738; also Zanotti and P. Matteucci, 1739; B. Zendrini, J. Poleni, F. M. Serra, E. Sguario and D. Revillas in 1738; G. Bianchi, 1738 and 1740; J. M. Serantoni, 1740; G. C. Cilano de Maternus, 1743; S. von Trienwald, 1744; G. Guadagni, 1744; J. F. Ramus, 1745; C. Nocetus, 1747; P. Matteucci, 1747; Jno. Huxham, 1749–1750; G. W. Krafft, 1750; P. Kahm—Kalm, 1752; G. Reyger, 1756; A. Hellant, 1756, 1777; Jos. Stepling, 1761; H. Hamilton, 1767, 1777; M. A. Pictet, 1769; J. E. Silberschlag, 1770; C. E. Mirus, 1770; J. E. B. Wiedeburg, 1771; Max. Hell, 1776; Mr. Hall, J. H. Helmuth, 1777; E. H. de Ratte, W. L. Krafft, 1778; J. E. Helfenzrieder, 1778; G. S. Poli, 1778–1779; Marcorelle and Darguier, 1782; L. Cotte, 1783; J. A. Cramer, 1785; D. Galizi, in A. Calogera's "Nuova Raccolta . . ." Vol. XXXIX. p. 64; J. L. Boeckmann, in "Mem. de Berlin" for the year 1780; H. Ussher, 1788; G. Savioli, 1789, 1790; J. J. Hemmer, 1790; P. A. Bondoli, 1790, 1792, 1802; A. Prieto, 1794; J. D. Reuss's works published in Göttingen; Jacopo Penada, 1807–1808; M. Le Prince, "Nouvelle Théorie . . ."; W. Dobbie, 1820, 1823; Col. Gustavson, in *Phil. Mag.* for 1821, p. 312; M. Dutertre, 1822; J. L. Späth, 1822; Chr. Hansteen, 1827, 1855; L. F. Kaemtz, 1828, 1831; G. W. Muncke, 1828; J. Farquharson, 1829; D. Angelstrom, Rob. Hare, 1836; Ant. Colla, 1836, 1837; L. Pacinotti, 1837; G. F. Parrot, 1838; J. H. Lefroy, 1850, 1852; Don M. Rico-y-Sinobas, 1853; A. A. de La Rive, 1854; A. Boué (*Katalog*), 1856, 1857; C. J. H. E. Braun, 1858; E. Matzenauer, 1861; F. Dobelli, 1867; F. Denza, 1869.

A.D. 1793–1797.—Robison (John), a very distinguished English natural philosopher, completes what are without question the most important of all his scientific publications. These are to be found

throughout the eighteen volumes and two supplements to the third "Encyclopædia Britannica," where they cover such subjects as Physics, Electricity, Magnetism, Thunder, Variation, etc. etc. Taken together, "they exhibited," according to Dr. Thomas Young, "a more complete view of the modern improvements of physical science than had previously been in the possession of the British public."

It was after his retirement from the navy that Robison devoted himself to scientific studies, becoming the successor of Dr. Black in the lectureship of chemistry at the University of Glasgow during 1766, and accepting, seven years later (1773), the Professorship of Natural Philosophy at Edinburgh, where he taught all branches of physics and of the higher mathematics. In 1783 he was made Secretary of the Philosophical Society of Edinburgh, received the degree of Doctor of Laws, 1798–1799, and was elected foreign member of the Saint Petersburg Academy of Sciences in 1800. Of him, Mr. James Watt wrote, Feb. 7, 1805: "He was a man of the clearest head and the most science of anybody I have known" (Arago's "Eloge of Jas. Watt," London, 1839, p. 81).

It was while acting as midshipman under Admiral Saunders that Robison himself observed the effect of the aurora borealis on the compass, which had been remarked by Hiörter, Wargentin, and Mairan several years before, but which was not then generally known. The aurora borealis, he afterwards wrote, "is observed in Europe to disturb the needle exceedingly, sometimes drawing it several degrees from its position. It is always observed to increase its rate of deviation from the meridian; that is an aurora borealis makes the needle point more westerly. This disturbance sometimes amounts to six or seven degrees, and is generally observed to be greatest when the aurora borealis is most remarkable. . . . Van Swinden says he seldom or never failed to observe aurora boreales immediately after any anomalous motion of the needle, and concluded that there had been one at the time, though he could not see it. . . . This should farther incite us to observe the circumstance formerly mentioned, viz., that the South end of the dipping needle points to that part of the heavens where the rays of the aurora borealis appear to converge. . . ."

The experiments of J. H. Lambert (at A.D. 1766–1776) upon the laws of magnetic action were carefully repeated by Robison, who, in 1769 or 1770, tried various methods and made numerous investigations from which he deduced that the force is inversely as the square of the distance. When he observed, however, some years afterward, that Æpinus had in 1777 conceived the force to vary inversely as the simple distance, he carefully again repeated the

experiments and added others made with the same magnet and with the same needle placed at one side of the magnet instead of above it. By this simple arrangement the result was still more satisfactory, and the inverse law of the square of the distance was well established.

Throughout his numerous investigations, Prof. Robison found that when a good magnet was struck for three-quarters of an hour, and allowed in the meantime to ring, its efficacy was destroyed, although the same operation had little effect when the ringing was impeded; so that the continued exertion of the cohesive and repulsive powers appears to favour the transmission of the magnetic as well as of the electric fluid. The internal agitation, produced in bending a magnetic wire around a cylinder, also destroys its polarity, and, it is said, the operation on a file has the same effect. M. Cavallo found that brass becomes generally much more capable of being attracted when it has been hammered, even between two flints; and that this property is again diminished by fire: in this case, Dr. Thomas Young remarks, it may be conjectured that hammering increases the conducting power of the iron contained in the brass, and thus renders it more susceptible of magnetic action.

Of his other very important observations in the same line it would be difficult to select the most interesting, and it may suffice to call attention merely to such as are noted throughout Prof. Alfred M. Mayer's valuable contributions on "The Magnet, Magnetism," etc., in Johnson's "New Universal Encyclopædia," as well as in his "Practical Experiments in Magnetism," etc., published through the columns of the *Scientific American Supplement*.

Prof. Robison's electrical investigations are scarcely less interesting. In the theories advanced by Æpinus and Cavendish it was shown that the action of the electrical fluid diminished with the distance, while M. Coulomb proved, by a series of elaborate experiments, that it varied like gravity in the inverse ratio of the square of the distance. Robison had previously determined that in the mutual repulsion of two similarly electrified spheres the law was slightly in excess of the inverse duplicate ratio of the distance, while in the attraction of oppositely electrified spheres the deviation from that ratio was in defect; and he therefore arrived at the same conclusion formed by Lord Stanhope, that the law of electrical attraction is similar to that of gravity.

At the close of Richard Fowler's "Experiments and Observations," etc., Edinburgh, 1793, is a letter from Prof. Robison, wherein he gives the following results of many curious investigations, mostly made upon himself, to ascertain the effects of the galvanic influence. He found the latter influence well defined on applying one of two

metallic substances to a wound which he had accidentally received; discovered by their tastes the solders in gold and silver trinkets; and showed that the galvanic sensation can be felt when the metallic substances are placed at a distance from each other. He proved the last-named fact by placing a piece of zinc between one of the cheeks and the gums, and a piece of silver on the opposite side within the other cheek. He next introduced a zinc rod between the piece of zinc and the cheek on the one side, and a silver rod between the silver and the cheek on the other, and when he afterward carefully brought into contact the extremities of the rods outside the mouth a flash appeared and a powerful sensation was noticeable in the gums. He experienced the same sensation when he again separated the rods and brought them to a short distance from each other, but he could perceive no galvanic effect when he placed the rods (or wires) in such manner that the silver rod should touch the zinc or the zinc rod touch the piece of silver. He also ascribed to galvanic effect the well-known fact that the drinking of porter out of a pewter pot produces a more brisk sensation than when it is taken out of a glass vessel. In this instance, he says there is a combination of one metal and of two dissimilar fluids. In the act of drinking, one side of the pewter pot is exposed to the saliva and the humidity of the mouth, while the other metallic side is in contact with the porter. In completing the circuit, in the act of drinking, a brisk and lively sensation arises, which imparts an agreeable relish to the liquid. He likewise observed that the conducting power of silk thread depends greatly on its colour, or rather on the nature of its dye. When of a brilliant white, or a black, its conducting power is the greatest; while either a high golden yellow or a nut-brown renders it the best insulator. Human hair, when completely freed from everything that water could wash out of it, and then dried by lime and coated with lac, was equal to silk.

Robison's last publication was made in 1804, one year before his death, and constituted the first part of a series which was to appear under the head of "Elements of Mechanical Philosophy." This portion, together with some MSS. intended for the second part, and his principal articles contributed to the "Encyclopædia Britannica," were collected in 1822 by Sir David Brewster, and published with notes in 4 vols. under the title of "System of Mechanical Philosophy."

References.—Playfair in "Transactions of the Royal Society of Edinburgh," Vol. VII. p. 495; Stark's "Biographia Scotica"; *Philosophical Magazine*, Vol. XIII. pp. 386–394 (Biogr. Memoir); Aikin's "General Biography," London, 1813, Vol. VIII; Dr. Gleig in *Anti-Jacobin Magazine* for 1802, Vol. XI; Chalmer's "Biographical Dictionary," London, 1816, Vol. XXV; Dr. Thomas Young, "Course of Lectures," London, 1807, Vol. II. pp. 438, 444.

A.D. 1793.—Prof. Georg. Fred. Hildebrandt of Erlangen (1764–1816), makes important observations relative to the influence of form and of substance upon the electric spark. He finds, among other results, that an obtuse cone with an angle of fifty-two degrees gives a much more luminous spark than one with an angle of only thirty-six degrees; that the greatest sparks are given by conical pieces of regulus of antimony and the least by tempered steel; also, that when the spark is *white* by taking it with a metallic body, it will, under the same circumstances, be *violet* if taken with the finger; that if the spark is taken with ice or water, or a green plant, its light will be red, and, if it is taken with an imperfect conductor, such as wood, the light will be emitted in faint red streams.

REFERENCES.—Biography in fifth ed. of "Lehrbuch der Physiologie des Mens. Koerpers," Erlangen, 1817; "Encyl. Britannica," Vol. VIII, 1855, pp. 544, 545; "Biog. Générale," Vol. XXIV. pp. 671–672; Ersch und Gruber, "Allgem. Encyklopædie."

A.D. 1794.—Read (John), mathematical instrument maker, at the Quadrant, in Kingsbridge, Hyde Park, gives, in his "Summary View of the Spontaneous Electricity of the Earth and Atmosphere," the result of a very elaborate series of observations, which he continued almost hourly between the years 1791 and 1792. Of 987 trials, he found that 664 gave indications of positive electricity, and out of 404 trials made during twelve months, the air was positively electrical in 241, negatively in 156, and insensible in only seven observations. He also found the vapour near the ground, in the act of condensing into dew, always highly electric.

He made many observations upon the electricity of vegetable bodies, which were afterward developed by M. Pouillet, and it was also Mr. Read who introduced a new hand-exploring instrument as well as an improved fixed thunder rod for collecting atmospherical electricity. These are described at p. 608 of the eighth volume of the 1855 "Encyclopædia Britannica."

According to Mr. Wilkinson ("Elements of Galvanism," etc., London, 1804, Vol. II. p. 344), Mr. Read was the first to apply the apparatus called the condenser to the electroscope in order that it should evince small intensities of electricity. He says: "The very minute portion of the fluid given out by the single contact of two different metals, does not produce any disturbance of the gold leaves; but when several minute portions are accumulated, a separation of the leaves takes place. The electroscope, in its simple state, will be as much charged the first time as if the contact had been made a thousand times, and cannot therefore acquire a greater quantity of the fluid than suffices to place it *in equilibrio* with the metallic plates. This portion being inadequate to the

production of any divergency of the leaves, Mr. Read applied the principle of the electrical doubler to the above instrument, by which means he was enabled to charge an intervening plate of air. By thus accumulating every minute portion of the fluid imparted through the metallic plate, and by apparently condensing and increasing its intensity, he ultimately succeeded in producing marked signs of disturbance."

REFERENCES.—*Philosophical Transactions* for 1791, p. 185; for 1792, p. 225; for 1794, pp. 185, 266: also Hutton's abridgments, Vol. XVII. pp. 52, 207, 423; "Bibl. Britan.," Vol. II, 1796, p. 209; Vol. III, 1796, p. 272; Vol. X, an. vii. p. 283; Cavallo, "Nat. Phil.," 1825, Vol. II. p. 226; Young's "Course of Lectures," Vol. I. p. 714; Ed. Peart, "On Electric Atmospheres . . ." Gainsboro', 1793; "Eng. Ency.," "Arts and Sciences," Vol. III. p. 805; Thomas Thomson, "Outline of the Sciences," 1830, p. 446; *Journal de Physique* for 1794, Vol. XLV. p. 468.

A.D. 1794.—Chladni (Ernst Florens Friedrich), founder of the theory of acoustics, publishes "The Iron Mass of Pallas," etc. ("Ueber den Ursprung der von Pallas . . ."), giving a list of recorded cases of the fall of meteorites or aerolites and all the important accounts of such that he was able to collect. As Prof. Alexander Herschel informs us, in his lecture, delivered (1867) before the British Association at Dundee, Chladni conceived that a class of cosmical bodies exists in all parts of the solar system, each forming by itself a peculiar concourse of atoms, and that the earth from time to time encounters them, moving with a velocity as great as its own, and doubtless in orbits of very various eccentricity around the sun. Prof. Muirhead says that through their exceeding great velocity, which is increased by the attraction of the earth and the violent friction of the atmosphere, a strong electricity and heat must necessarily be excited, by which means they are reduced to a flaming and melted condition, and great quantities of vapour and different kinds of gases are thus disengaged, which distend the liquid mass to a monstrous size, until, by still further expansion of these elastic fluids, they must at length explode (Chladni's hypothesis in "Enc. Brit.," article "Meteorolite").

Humboldt gives ("Cosmos," London, 1849, Vol. I. p. 104, note) the following upon the same subject, taken from Biot's "Traité d'Astronomie Physique," third edition, 1841, Vol. I. pp. 149, 177, 238, 312: "My lamented friend Poisson endeavoured in a singular manner to solve the difficulty attending an assumption of the spontaneous ignition of meteoric stones at an elevation where the density of the atmosphere is almost null. These are his words: 'It is difficult to attribute, as is usually done, the incandescence of aerolites to friction against the molecules of the atmosphere, at an elevation above the earth where the density of the air is almost

null. May we not suppose that the electric fluid, in a neutral condition, forms a kind of atmosphere, extending far beyond the mass of our own atmosphere, yet subject to terrestrial attraction, although physically imponderable, and consequently following our globe in its motion? ' According to his hypothesis, the bodies of which we have been speaking would, on entering this imponderable atmosphere, decompose the neutral fluid by their unequal action on the two electricities, and they would thus be heated, and in a state of incandescence, by becoming electrified" (Poisson, "Rech. sur la Probabilité des Jugements," 1837, p. 6).

The theories advanced by Chladni were confirmed four years later by Brandes and Benzenberg at Göttingen, and, during the month of April 1809, he inserted a "Catalogue of Meteors" in the "Bulletin de la Société Philomathique," which was followed by a paper on "Fiery Meteors" published at Vienna during 1819.

In his "Traité d'Acoustique," Chladni treats of the line of experiments to which he was led, as well by the discovery of Lichtenberg's electrical figures (see A.D. 1777, and Tyndall, "Sound," Lecture IV), an account of which latter appeared in the "Mémoires de la Société Royale de Göttingen," as through the suggestions made him by Lichtenberg himself during the year 1792 relative to the origin of meteors. The results of Chladni's researches concerning the last named appeared in a Memoir published at Leipzig during 1794, translated by M. Eugène Coquebert Mombret for Vol. V of the *Journal des Mines*.

It may here be properly added that, in one of the editions of his "Lectures on Sound," Prof. Tyndall gives a portrait of Chladni and quotes a letter received from Prof. Weber wherein he says: "I knew Chladni personally. From my youth up he was my leader and model as a man of science, and I cannot too thankfully acknowledge the influence which his stimulating encouragement during the last years of his life had upon my own scientific labours."

REFERENCES.—Quetelet (Lambert A. J.) in "Cat. Sc. Pap. Roy. Soc.," Vols. V, VI, VIII; "Mém. de l'Acad. Roy. de Brux.," 1830–1842; "Annali" of Ambroglio Fusinieri for 1854; "Phil. Mag.," 1851; Secchi (Angelo) in "Cat. Sc. Pap. Roy. Soc.," Vols. V, VIII; "Bull. Meteor. dell Osservat.," 1862, 1866, 1867; Humboldt's "Cosmos," London, 1849, Vol. I. p. 104 (M. Schreiber), pp. 113, 114 (M. Capocci), also pp. 105, 108, 110, 121, and the entire "Review of Natural Phenomena," with all the important references and notes thereunto attached. See likewise Peter Simon Pallas (*Phil. Trans.* for 1776 and "Act. Acad. Petrop.," I for 1778); Chladni's "Uber . . . elektricität einer Katze," Jena, 1797; J. Acton and Capel Lofft, in *Phil. Mag.*, Vol. LI. pp. 109, 203; A Seguin, *Phil. Mag.*, Vol. XLIV. p. 212; Houzeau et Lancaster, "Bibl. Gén.," Vol. II. pp. 714, 762, for étoiles, filantes et météorites; F. B. Albinus, "Specimen," etc., 1740; Voigt's "Magaz.," I, 1797; Schweigger's *Journal*, XLIII, 1825; H. Atkinson, "On Hypotheses," etc. (*Phil. Mag.*, Vol. LIV. p. 336); Karstner, *Archiven*, Vol. IV; F. C. Von Petersdorff in

" Great Divide "; Pierre Prevost and others in Poggendorff's *Annalen*, Vols. II, VI and VII; Arago, " Annuaire pour 1826 "; " The fall of Meteorites in Ancient and Modern Times " (" Sc. Progress," Vol. II. N.S., pp. 349–370: numerous references given by Prof. H. A. Miers; " A Century of the Study of Meteorites," by Dr. Oliver C. Farrington in "Pop. Sc. Monthly," Feb. 1901, or the Report of Smiths. Instit. for 1901, pp. 193–197; *Phil. Mag.*, Vol. IV. p. 332; " Cat. Sc. Papers . . . Roy. Soc.," Vol. I. pp. 916–918; D. Avelloni " Lettera," etc., Venezia, 1760; Martin H. Klaproth's different memoirs published at Berlin 1795–1809; Joseph Izarn, " Lithologie Atmosphérique "; J. Murray (*Phil. Mag.*, Vol. LIV. p. 39); beside Chladni's works in conjunction with Karl F. Anton von Schreibers, Wien, 1819 and 1820, and with Messrs. Steininger and Næggerath, London, 1827. (Schweigger's *Journal*, N.R., XVI. 385, and *Phil. Mag.*, Vol. II. p. 41, also Vol. IV. p. 332). For a very interesting account, see " A description of the great Meteor which was seen on the 6th of March 1715–1716, sent in a letter . . . to R. Danuye . . ." London, 1723 (*Phil. Trans.* for 1720–1721, Vol. XXXI), by Roger Cotes (1682–1716), of whom Sir Isaac Newton entertained so high an opinion as to frequently remark: " *If Mr. Cotes had lived, we had known something* " (" Biographia Philosophica," pp. 512–516; English Encycl., " Biography," Vol. II. p. 401). Other exceedingly interesting accounts of aerolites are to be found, more particularly in Frederic Petit's works, published at Toulouse, in Bigot de Morogue's "Catalogue," London, 1814, and in the *Phil Mag.*, Vols., XVII, XX, XXVIII, XXXII, XXXVI, XLIII, XLVI, XLVIII, L, LIII, LIV, LVI–LIX, LXII. While treating of this subject, it may be well to add here that up to the year 1887 diamonds were not known to exist in meteorites. In a very remarkable paper by Prof. A. E. Foote, read before the Geological section of the Am. Asso. Adv. Sci., at its meeting in Washington, he described having, during the month of June 1891, explored Crater Mountain (Cañon Diablo), 185 miles north of Tucson, Ariz., where he found some extraordinary specimens. The extreme hardness of one of these attracted particular attention, and upon carefully examining it he discovered in some of the cavities many small black diamonds as well as a white diamond one-fiftieth of an inch in diameter. This is said to be the most extensive find of the kind yet made.

A.D. 1794.—Mr. J. Churchman publishes his improved " Magnetic Atlas or Variation Charts of the whole terraqueous globe," etc., which Sir John Leslie subsequently pronounced the most accurate and complete hitherto made. The charts preceding it worthy of note were those of Dr. Halley (see A.D. 1683), of Mountaine and Dodson, in 1744 and in 1756, of Wilcke, in 1772, and of Lambert, in 1779. In his charts, Churchman refers variation lines to two poles, one of which he places, for the year 1800, in lat. 58° N. and long. 134° W. of Greenwich, while the other pole is in lat. 58° S. and long. 165° E. of Greenwich. He supposes the northern pole to revolve in 1096 years and the southern one in 2289 years (" Ency. Brit.," 1857, Vol. XIV. p. 49).

References.—Churchman's letters to Cassini, Phila., 1788, and his " Explanation of the Magn. Atlas . . ." 1790; Harris, " Rudim. Mag.," Part III. p. 101; " Bibl. Britan.," Vol. II. 1796, p. 325 (atlas); Becquerel, " Traité d'Electr. et de Magn.," Paris, 1856, III. p. 140.

A.D. 1794.—M. Reusser Reiser, of Geneva, addresses a letter

to the "Magazin für das Neueste aus der Physik" of Johann Heinrich Voigt (Vol. IX. part i. p. 183), describing the construction of "a new species of electric letter post" ("Schreiben an den herausgeber") in the following words: ". . . on an ordinary table is fixed, in an upright position, a square board, to which a glass plate is fastened. On this plate are glued little squares of tinfoil, cut after the fashion of luminous panes, and each standing for a letter of the alphabet. From one side of these little squares extend long wires, enclosed in glass tubes, which go underground to the place whither the despatch is to be transmitted. The distant ends are there connected to tinfoil strips, similar . . . to the first, and, like them, each marked by a letter of the alphabet; the free ends of all the strips are connected to one return wire, which goes to the transmitting table. If, now, one touches the outer coating of a Leyden jar with the return wire, and connects the inner coating with the free end of that piece of tinfoil which corresponds to the letter required to be indicated, sparks will be produced, as well at the near as at the distant tinfoil, and the correspondent there watching will write down the letter. . . ."

Reusser also suggested calling the attention of the correspondent by firing an electrical pistol through the spark; to him, therefore, belongs the credit of having first clearly indicated the use of a special call for the telegraph.

REFERENCES.—Vail's "History," p. 121; Voigt's "Magazin . . ." Vol. VII. part ii. p. 57; Shaffner, "Manual," pp. 133, 134; Forster's "Bauzeitung," 1848, p. 238; Ed. Highton, p. 38; Sabine, p. 11; "Appleton's Encycl.," 1871, Vol. XV. p. 335; Reiser, "Der El. Würfel," Gotha, 1791; *Comptes Rendus*, Tome VII for 1838, p. 80.

A.D. 1794.—Prof. Boeckmann improves upon Reusser's idea, and does away with the thirty-six plates and the seventy-two wires which the latter is believed to have employed. As Dr. Schellen expresses it, he used "the sparks passing at the distant station, employing only two wires, through which first one and then, after certain intervals, more sparks are combinedly grouped" in a way to indicate particular letters. Like Reusser, he made use of the pistol as a call signal.

REFERENCES.—Zetzsche, "Geschichte der Elektrischen Telegraphie," p. 32; Boeckmann, "Versuch über Telegraphie und Telegraphen," Carlsruhe, 1794, p. 17; "El. Magn. Teleg.," 1850, p. 46; Gren's *Journal der Physik*, Vol. I for 1790; "Neue Abhandl. der Bairischen Akad. Philos.," Vol. III.

A.D. 1794.—Edgeworth (Richard Lovell), an able English mechanical philosopher, better known as the father and literary associate of Maria Edgeworth, introduces his *tellograph* (contraction

of the word *telelograph*), " a machine describing words at a distance," which originated in a wager relative to the prompt transmission of racing news from Newmarket to London. It consisted merely of four pointers, in the form of wedges or isosceles triangles, placed upon four portable vertical posts and the different positions of which were arranged to represent letters and numbers.

Edgeworth claimed to have made experiments, as early as 1767, with an ordinary windmill, the arms and sails of which were arranged in different positions to indicate the several letters of the alphabet.

References.—Edgeworth's Letter to Lord Charlemont on the Tellograph, also his " Essay on the Art of Conveying Secret and Swift Intelligence," Dublin, 1797, republished in Vol. VI of the *Trans. of the Royal Irish Academy; "* Appleton's Encycl.," 1871, Vol. XV. p. 334.

A.D. 1795.—Lord George Murray, of England, submits to the Admiralty his six-shutter telegraph, an improvement upon Chappe's original plan. Each of the six octagonal shutters was made to turn inside of two frames at different angles upon its own axis, thus affording sixty-three separate and distinct signals. By its means, information was transmitted from London to Dover in seven minutes, and it answered nearly all the requirements of the Admiralty up to the year 1816, when it was superseded by the semaphore of Rear Admiral Popham. Murray's method was, however, useless during foggy weather, when relays of horses had to be employed for conveying the news.

References.—English Encyclopædia, " Arts and Sciences," Vol. VIII. p. 66; Tomlinson's " Telegraph "; Turnbull, *El. Mag. Tel.*, 1853, p. 18; " Penny Ency.," Vol. XXIV. p. 147.

A.D. 1795.—Salvá (Don Francisco), a distinguished Spanish physician, reads a memoir, before the Academy of Sciences of Barcelona, from which the following is extracted: " . . . with twenty-two letters, and even with only eighteen, we can express with sufficient precision every word in the language, and, thus with forty-four wires from Mataro to Barcelona, twenty-two men there, each to take hold of a pair of wires, and twenty-two charged Leyden jars here, we could speak with Mataro, each man there representing a letter of the alphabet and giving notice when he felt the shock. . . . It is not necessary to keep twenty-two men at Mataro nor twenty-two Leyden jars at Barcelona, if we fix the ends of each pair of the wires in such a way that one or two men may be able to discriminate the signals. In this way six or eight jars at each end would suffice for intercommunication, for Mataro can as easily speak with Barcelona as Barcelona with Mataro . . . or the wires can be rolled together in one strong cable . . . laid in subterranean tubes,

which, for greater insulation, should be covered with one or two coats of resin."

He is said to have approved of the use of luminous panes as indicated by Reusser; to have also suggested, as early as December 16, 1795, the idea of a *submarine telegraphic cable* carrying several conductors, and to have proposed, at the same period, the laying of a cable between Barcelona and Palma in the island of Majorca.

In 1798, Salvá constructed a single wire telegraphic line between Madrid and Aranjuez, a distance of twenty-six miles, through which the signals were transmitted in the shape of sparks from Leyden jars. This is the line which is credited to Augustin de Bétancourt, a French engineer, by Alexander Von Humboldt, in a note at p. 14 of Gauss and Weber's *Resultate*, etc., for the year 1837.

On the 14th of May 1800, and on the 22nd of February 1804, Salvá communicated to the Academy of Sciences at Barcelona two papers on galvanism applied to electricity, wherein he shows that a cheaper motive power is produced by the electricity of a number of frogs, and proposes a telegraphic apparatus in conjunction with the voltaic column which is illustrated and described at pp. 224 and 225 of Fahie's "History of Telegraphy." From the latter the following is taken: "This illustrious Spanish physician (Salvá) was therefore the first person who attempted to apply electricity dynamically for the purpose of telegraphing. It is, says Saavedra, not without reason, I must confess, notwithstanding my cosmopolitan opinions on scientific questions, that *the Catalans hold Salvá to be the inventor of electric telegraphy*. With documents as authentic as those which I have seen with my own eyes in the very hand writing of this distinguished professor (which documents are at this present moment to be found in the library of the Academy of Sciences of Barcelona) it is impossible for any author to henceforth deny, even if others did precede Salvá in telegraphic experiments with static electricity, that no one preceded him in the application of the docile electrodynamic fluid to distant communications."

References.—*Comptes Rendus*, séance, 1838; Memorial of Joseph Henry, 1880, p. 224; Ed. Highton, the *El. Tel.*, 1852, pp. 38 and 43; "Appleton's Encyclopædia," 1871, Vol. XV. p. 335; *De Bow's Review*, Vol. XXV. p. 551; Voigt's *Magazin*, etc., Vol. XI. part iv. p. 61; *Sc. Am. Supp.*, No. 547, p. 8735, and No. 384, p. 6127; Biography in Saavedra's *Revista*, etc., for 1876; Noad's *Manual*, pp. 747 and 748; Shaffner, *Manual*, p. 135; Turnbull, *El. Mag. Tel.*, 1853, pp. 21, 22, 220; Du Moncel, *Exposé*, Vol. III; "Edinburgh Encyclopædia," London, 1830, Vol. VIII. p. 535; "Gazette de Madrid" of November 25, 1796; "Mémoires de l'Institut," Vol. III and "Bulletin de la Soc. Philom.," An. VI for the new telegraph of MM. Bréguet and Bétancourt, and for the Report made thereon by MM. Lagrange, Laplace and others.

A.D. 1795.—Ewing (John), D.D., Provost of the University of Pennsylvania and one of the founders of the American Philosophical Society, makes a compilation of his course of lectures on natural experimental philosophy, which is subsequently revised for the press by Prof. Robert Patterson.

He devotes much attention to atmospheric electricity, detailing the Franklinian theory, and, besides reporting upon the hypotheses advanced by Henry Eales (at A.D. 1755), as well as treating of the attraction of magnetism, he gives a very interesting account of experiments with the *torpedo* and the *gymnotus electricus.* He says that Mr. Walsh found the *torpedo* "possessed of the power of shocking only in two parts of its body, directly opposite to each other and near to the head. A spot on the back and another on the belly opposite to the former being of a different colour led him to make the experiment, and he found that the electrical virtue was confined to these, and that any other part of the fish might be handled, without receiving a shock, while it was out of the water. Either of these places separately might be handled without the shock being received until a communication between them was formed. This makes it appear probable that the same may also be the case with the Guiana eel. One of these spots must therefore be always in the positive and the other in the negative state; or, rather, they are both generally in the natural state, until, by an effort of the fish's will, they are suddenly put into different states, as we frequently found that the hand might be in the water, which formed the communication, without receiving any shock. This cannot be the case with the Leyden bottle when charged, which suddenly discharges itself upon forming the communication. Whether there be any electric atmosphere round these spots in the *torpedo* we cannot tell, as we had no opportunity of examining this matter in the eel, nor have we heard whether Mr. Walsh made any experiments for ascertaining this."

Electricity of the Atmosphere

The investigations of John Ewing concerning atmospheric electricity were in reality quite extensive. He not only repeated the experiments of Franklin, but he examined thoroughly those of other scientists in the same channel, especially the investigations of Henry Eeles, which will be found detailed in the latter's "Trinity College Lectures" as well as in his "Philosophical Essays," London, 1771.

For a very interesting historical review of theories as to the origin of atmospherical electricity, it would be well to consult

Date	Name	Experiments	References
1751	Franklin	Effects of lightning	Phil. Trans., xlvii. p. 289
1751	Mazeas	Kite experiments independently of Franklin	Phil. Trans., 1751–1753
1752	Nollet	Theory of Electricity	Recher. sur les causes, 1749–1754 Lettres sur l'élect., 1753, 1760, 1767, 1770
1752	Watson	Electricity of clouds	Phil. Trans., 1751, 1752
1752	De Lor and Buffon	Iron pole 99 ft. high, mounted on a cake of resin 2 ft. sq., 3 in. high, Estrapade, May 18, 1752	Letter of Abbé Mazeas, dated St. Germain, May 20, 1742
1752	D'Alibard	Sparks from thunder clouds, 40 ft. pole in garden at Marly, also wooden pole 30 ft. high, at Hôtel de Noailles	Mem. l'Acad., r. des Sci., May 13, 1762 Hist. Abrégée, 1776
1752	Le Monnier	Observations of air charge	Mém. de Paris, 1752, pp. 8, 233
1752	De Romas	Observations of air charge; kite experiments	Mém. Sav. Etrangers, 1752, and Mém. de Math., 1755, 1763
1752	Mylius, Ch.	Observations of air charge	"Nachrichten," Berlin, 1752
1752	Kinnersley	Observations of air charge	Franklin's Letters, Phil. Trans., 1763, 1773
1752	Ludolf and Mylius	Observations of air charge	Letter to Watson
1753	Richman	Electrical gnomon	Phil. Trans., 1753
1753	Canton	Electricity of clouds	Franklin's letters and Phil. Trans., 1753
1753	Beccaria, C.B.	Systematic observations with an electroscope	Lett. dell' Elet. Bologna, 1758
1753	Wilson	Experiments	Phil. Trans., 1753, p. 347
1754	Lining	Kite experiments	Letter to Chas. Pinckney
1755	Le Roy	Experiments	Mém. de Paris, 1755
1756	Van Musschenbroek	Kite experiments	Intro. ad Phil. Nat., 1762
1759	Hartmann	Origin of electricity	Verbesseter . . . Blitzes (*Hamb. Mag.* vol. xxiv.
1769	Cotte	Memoirs on meteorology	Journ. Phys., xxiii., 1783 Mém. Paris, 1769–1772
1772	Ronayne	Fog observations	Phil. Trans., 1772, p. 137
1772	Henley	Quadrant electrometer	Phil. Trans., 1772–1774
1775	Cavallo	Fogs, snow, clouds and rain; kite experiments	Treatise on Elect., 1777
1784	De Saussure	Observations	"Voyages dans les Alpes," Geneva, 1779–1796
1786–7	Mann	Daily observations with an electrical machine, timing the revolutions to produce a given spark with a record of the weather	Ephemer. Météorol. of the Mannheim Society, 1786–1792
1788	Volta	New electroscope	Lettere Sulla Meteor, 1788–1790
1788	Crosse	Experiments with collectors	Gilb. Ann., Bd. 41, s. 60
1791	Read	Insulation and conductors	Phil. Trans., 1791 and Summary, 1793
1792	Von Heller	Observations	Gren, "*Neues Journ. der Phys.*," vol. ii. 1795 and vol. iv. 1797
1792	Schubler	Observations with weather rod	J. de Phys., lxxxiii. 184

M. A. B. Chauveau's article in "Ciel et Terre," Bruxelles, March 1, 1903, and also Humboldt's "Cosmos," London, 1849, Vol. I. pp. 342–346. In the last-named work are cited: Arago, "Annuaire," 1838, pp. 246, 249–266, 268–279, 388–391; Becquerel, "Traité de l'Electricité," Vol. IV. p. 107; De la Rive, "Essai Historique," p. 140; Duprez, "Sur l'électricité de l'air," Bruxelles, 1844, pp. 56–61; Gay-Lussac, "Ann. de Ch. et de Phys.," Vol. VIII. p. 167; Peltierin, "Ann. de Chimie," Vol. LXV. p. 330, also in "Comptes Rendus," Vol. XII. p. 307; Pouillet, "Ann. de Chimie," Vol. XXXV. p. 405.

An attractive table, which we are permitted to rearrange and reproduce here, giving a *résumé* of references to some of the most noted experiments of the chief investigators from the time of Franklin to the end of the eighteenth century, was made up by Mr. Alex. McAdie and first appeared in the "Amer. Meteor. Journal." Mr. McAdie says that a detailed history of most of Franklin's co-labourers will be found in the accounts given by Exner,[1] Hoppe,[2] Mendenhall,[3] Elster and Geitel[4] as well as by himself,[5] and that in making up this table he has passed over Peter Collinson, of London, who introduced to the notice of the Royal Society the experiments of Franklin, and the three less-known workers—J. H. Winkler, who wrote in 1746 on the electrical origin of the weather lights; Maffei, 1747; and Barberet, 1750.

A.D. 1795.—The telegraphs of the Rev. J. Gamble, Chaplain to the Duke of York, consisted either of five boards placed one above the other or of arms pivoted at the top of a post upon one axis and capable of producing as many signals as there are permutations in the number five, all of the combinations being possible at equal angles of forty-five degrees. His doubts as to the practicability of employing electricity "as the vehicle of information" are fully expressed at p. 73 of his "Essay on the Different Modes of Communicating by Signal," etc., London, 1797.

[1] Ueber die Ursache und die Gesetze der atmosphärischen Elektricität. Von Prof. Franz Exner. Repertorium der Physik. Band XXII. Heft 7.

[2] Ueber Atmosphärischen und Gewitter Elektricität. Meteor. Zeits. 1, 2, 3 and 4, 1885.

[3] Memoir of National Academy of Sciences.

[4] (*a*) Report of Chicago Meteorological Congress. Part II. August 1893. (*b*) Zusammenstellung der Ergebnisse neuerer der Arbeiten über atmosphärische Elektricität. Von J. Elster und H. Geitel. Wissen. Beilage zum Jahresbericht des Herzoglichen Gymnasiums zu Wolfenbuttel, 1897.

[5] (*a*) Observations of Atmospheric Electricity. American Meteorological Journal, 1887. (*b*) Terrestrial Magnetism. December 1897.

Consult Sir Wm. Thomson (Lord Kelvin), "Reprint of Papers on Electrostatics and Magnetism," London, 1884, second edition, pp. 192–239, Chapter (Article) XVI, "Atmospheric Electricity."

References.—J. Gamble, " Observations on Telegraphic Experiments," etc.; Article " Telegraph " in Tomlinson's " Encyl. of Useful Arts "; " Penny Ency.," Vol. XXIV. pp. 147 and 148; "English Cyclopædia," " Arts and Sciences," Vol. VIII. p. 66.

A.D. 1795.—Garnet (John), proposes a telegraph consisting of only one bar moving about the centre of a circle, upon which latter the letters and figures are inscribed. On placing corresponding divisions, by means of wires, before the object glass of the telescope the coincidence of the two radii or of the arm would point out the letter intended to be repeated. As this plan proved impracticable for long distances, it did not come into general use (" Emporium of Arts and Sciences," Phila., 1812, Vol. I. p. 293).

A.D. 1795.—Wells (Charles William), a physician, native of South Carolina but practising in England and a F.R.S., publishes in the *Phil. Trans.* a paper on the influence which incites the muscles of animals to contract in Galvani's experiments. Therein he was the first to demonstrate that voltaic action is produced through charcoal combined with another substance of different conducting power, and this he did by causing noticeable convulsions in a frog through the combination of charcoal and zinc. (See " Ency. Met.," Vol. IV. pp. 220, 221, for the experiments of both Dr. Wells and Dr. Fowler.) Fahie states that Davy subsequently constructed a pile which consisted of a series of eight glasses containing well-burned charcoal and zinc, using a red sulphate of iron solution as the liquid conductor. It is said this series gave sensible shocks and rapidly decomposed water and that, compared with an equal and similar series of silver and zinc, its effects were much stronger. (See Priestley's discovery of the electrical conductibility of charcoal at A.D. 1767, and the description of Davy's charcoal battery in " Jour. Roy. Inst." and *Nicholson's Journal*, N. S., Vol. I. p. 144.)

His biographer, in the " Eng. Cyclop.," says (Vol. VI. pp. 631–632) that his last work and the one upon which his reputation as a philosopher must rest, is his " Essay upon Dew," published in 1814 (" Journal des Savants " for Sept. 1817), whilst J. F. W. Herschel remarks at p. 122 of his " Prel. Disc . . . Nat. Phil.," 1855: " We have purposely selected this theory of dew, first developed by the late Dr. Wells, as one of the most beautiful specimens we can call to mind of inductive experimental inquiry lying within a moderate compass. . . ."

References.—Wells' biography in the " English Cyclopædia," Vol. VI. p. 631; *Phil. Trans.* for 1795, p. 246; Hutton's abridgments of the *Phil. Trans.*, Vol. XVII. p. 548; Fahie's " History," etc., pp. 201

and 202; "Aristotle on Dew" (Poggendorff, *Geschichte der Phys.*, 1879, p. 42); Luke Howard, "On the Modification of Clouds . . ." London, 1803; C. H. Wilkinson, "Elements of Galvanism," etc., London, 1804, Vol. I. pp. 162–165 and Vol. II. p. 329.

A.D. 1796.—Gregory (George), D.D., F.R.S., Vicar of Westham, a miscellaneous writer of Scotch origin, for many years editor of the "New Annual Register," is the author of "Economy of Nature," etc., of which the second and third editions, considerably enlarged, appeared respectively in 1798 and 1804.

In the first volume of the last-named edition (Book I. chap. vi. pp. 35–54) he treats of natural and artificial magnets and of magnetic powers and theories of magnetism, while the whole of Book IV. (chaps. i.–viii. pp. 299–386) is devoted to the history of and discoveries relative to electricity, its principles and theories, as well as to electrical apparatus and electrical phenomena and to galvanism or animal electricity.

Gregory is also the author of "Popular Lectures on Experimental Philosophy, Astronomy and Chemistry; Intended Chiefly for the Use of Students and Young Persons," 2 vols., 12 mo, published in London 1808–1809, one year after Gregory's death.

It was the perusal of the latter work which led Joseph Henry to embrace a scientific career, just as the reading of "Mrs. Marcet's Conversations on Chemistry" had induced Michael Faraday to enter the field in which he afterward became so highly distinguished. Prof. Asa Gray, in his Biographical Memoir of Henry, says that Gregory's work alluded to is an unpretending volume but a sensible one, and that it begins by asking three or four questions, such as these: "You throw a stone, or shoot an arrow into the air; why does it not go forward in the line or direction that you give it? Why does it stop at a certain distance and then return to you? . . . On the contrary, why does flame or smoke always mount upward, though no force is used to send them in that direction? And why should not the flame of a candle drop toward the floor when you reverse it, or hold it downward, instead of turning up and ascending into the air? . . . Again, you look into a clear well of water and see your own face and figure as if painted there? Why is this? You are told that it is done by reflection of light. But what is reflection of light?" As Prof. Gray remarks, young Henry's mind was aroused by these apt questions, and allured by the explanations. He now took in a sense of what knowledge was. The door to knowledge opened to him, that door which it thence became the passion of his life to open wider. The above-named volume is preserved in Prof. Henry's library, and bears upon a fly-leaf the following entry:

"This book, although by no means a profound work, has, under

Providence, exerted a remarkable influence upon my life. It accidentally fell into my hands when I was about sixteen years old, and was the first work I ever read with attention. It opened to me a new world of thought and enjoyment; invested things before almost unnoticed with the highest interest; fixed my mind on the study of nature, and caused me to resolve at the time of reading it, that I would immediately commence to devote my life to the acquisition of knowledge. J. H." (See Prof. A. M. Mayer, "Eulogy of Joseph Henry," Salem, 1880, pp. 29–30; "Smithsonian Report," 1878, pp. 145, 146.)

References.—*Gentleman's Magazine*, Vol. LXVII. p. 415; Beloe's "Sexag.," II. 128; "Living Authors" (1798), I. p. 225.

A.D. 1797.—Bressy (Joseph), French physician and able chemist, remarks, in his "Essai sur l'électricité de l'eau," that the electric fluid is composed of three beams (*rayons*, i. e. rays, gleams, or sparks), vitreous, resinous and vital; that three principal agents exist in nature, viz. the air, isolating body; the water, conducting body, and movement, determining action; that vapours resolve themselves into clouds merely because friction enables the electric fluid to seize upon the aqueous molecules, and that, in water, the hydrogen is maintained in the form of gas by the electric fluid, while the oxygen becomes gaseous under influence of the caloric.

References.—Larousse, "Dict. Univ.," Vol. II. p. 1236; Delaunay, "Manuel," etc., 1809, pp. 15, 16.

A.D. 1797.—Treméry (Jean Louis), a French mining engineer, communicates his observations on elliptic magnets through Bulletin No. 6 of the "Société Philomathique" as well as through the sixth volume of the *Journal des Mines.*

His observations on conductors of electricity and on the emission of the electric fluid appear at p. 168 Vol. XLVIII of the *Jour. de Phys.*, and in "Bull. de la Soc. Philom.," No. 19, while his views in opposition to the two-fluid theory are to be found in Bulletin No. 63 of the last-named publication as well as in *Jour. de Phys.*, Vol. LIV. p. 357.

References.—Poggendorff, Vol. II. p. 1131; John Farrar, "Elem. of Elec.," etc., p. 120.

A.D. 1797.—Pearson (George), English physician and chemist, communicates to the Royal Society a very interesting paper entitled, "Experiments and Observations made with the view of ascertaining the nature of the gas produced by passing electric discharges through water; with a description of the apparatus for these experiments."

An abstract of the above appears in the *Phil. Trans.* for 1797, and a full transcript of it is to be found in *Nicholson's Journal*, 4to, Vol. I. pp. 241–248, 299–305, and 349–355.

As Mr. Wilkinson has it, " Dr. Pearson supposes the decomposition of water by electricity to be effected by the interposition of the dense electric fire, between the constituent elements of the water, which he places beyond the sphere of attraction for each other, each ultimate particle of oxygen and hydrogen uniting with a determinate quantity of the electric fire to bestow on them their gaseous form. Hence the doctor supposes that the electric fire, after effecting the disunion, assumes the state of caloric.

" On the reproduction of water by the passage of an electric spark through a proportionate quantity of oxygen and hydrogen gases, Dr. Pearson ingeniously conjectures that by the influence of the electric flame the ultimate particles of these gases, the nearest to the flame, are driven from it in all directions, so as to be brought within the sphere of each other's attractions. In one of these cases Dr. Pearson supposes that the caloric destroys the attraction, which in the other instance it occasions.

" It is with diffidence that I take on me to controvert the opinions of this very respectable physician; but I presume that the whole of the phenomena of the synthesis and analysis of water are more readily to be explained on the principles I have laid down than by the adoption of the mysterious terms of attraction and repulsion. By the operation of galvanism, water is more rapidly decomposed than by common electricity. In this operation there is no evolution of dense electrical fire, but merely a current of a small intensity of electricity acting permanently and incessantly. To reproduce water, a flame must be generated sufficient to kindle the contiguous portion of the hydrogen gas, then the next portion, and so on, the combustion being preserved by the presence of the oxygen gas. As these processes proceed with immense rapidity as soon as the gases are intermixed, so as to appear like one sudden explosion, the caloric of each of them being thus disengaged, their bases unite and constitute water."

Dr. Pearson also made many interesting experiments to ascertain the effect of the application of galvanic electricity for the treatment of diseases, and Noad, who describes one of his successful operations, also details (" Manual," pp. 343–349) the observations of many others in the same line, notably those of Drs. Apjohn, Majendie, Grapengieser and of Wilson Philip, Petrequin, Pravaz, Prevost and Dumas (*Jour. de Physiol.*, Tome III. p. 207), as well as of Sarlandière and Dr. Golding Bird, besides giving the very important conclusions arrived at by Stefano Marianini.

REFERENCES.—"Some Account of George Pearson," M.D., F.R.S. (*Phil. Mag.*, Vol. XV for 1803, p. 274); letter of Humboldt to M. Loder ("Bibl. Germ.," Vol. IV, Messidor, An. VIII. p. 301); William Van Barneveld, "Med. Elektricität," Leipzig, 1787; C. H. Wilkinson, "Elements of Galvanism," London, 1804, 2 vols. *passim;* Paragraph No. 328 of Faraday's "Experimental Researches," J. N. Hallé, "Journal de Médecine de Corvisart," etc., Tome I, Nivose, An. IX. p. 351; "Annales de l'Electricité Médicale" *passim;* H. Baker (*Phil Trans.*, Vol. XLV. p. 270); "Jour. de la Soc. Philom.," Messidor, An. IX; J. F. N. Jadelot, "Expériences," etc., 1799; M. Butet ("Bull. des Sc. de la Soc. Philom.," No. 43, Vendémiaire, An. IX); M. Oppermanno, "Diss. Phys. Med." (see J. G. Krunitz "Verzeichnis," etc.); Andrieux, "Mémoire . . . maladies," Paris, 1824; Lebouyer-Desmortiers (Sue, "Hist. du Galv.," Vol. II. p. 420, and *Jour de Phys.*, Prairial, An. IX, 1801, p. 467); C. J. C. Grapengieser, "Versuche den Galvanismus," etc., Berlin, 1801 and 1802; the works of J. Althaus, published in London and Berlin in 1859–1870; C. A. Struve's works, published in Hanover and Breslau, 1797–1805; F. L. Augustin's works, published in Berlin, 1801–1803; Karl Friedrich Kielmeyer (Kielmaier), works published at Tübingen (Poggendorff, Vol. I. p. 1253); Einhoff (Gilbert, XII. p. 230); Francesco Rossi's treatises on the application of galvanism, published in 1809; Gilb. "Ann.," Vol. XII. p. 450; *Jour. de Phys.*, Vol. LII. pp. 391 and 467; Cuthbertson's letter in *Phil Mag.*, Vol. XVIII. p. 358; J. G. Anglade, "Essai sur le Galvanisme," etc. (Sue, "Hist. du Galv.," Vol. III. p. 73); Jacques Nauche, in *Phil. Mag.*, Vol. XV. p. 368, as well as in Poggendorff, Vol. II. p. 256, and throughout the "Journal du Galvanisme."

A.D. 1797.—In No. CCXXII of the *Reichsanzeiger*, a German publication, it is said that a certain person having an artificial magnet suspended from the wall of his study with a piece of iron adhering to it, remarked, for several years, that the flies in the room, though they frequently placed themselves on other iron articles, never settled upon the artificial magnet.

REFERENCES.—Cavallo, "Experimental Philosophy," 1803, Vol. III. p. 560, or the 1825 Philad. ed., Vol. II. p. 286.

A.D. 1797–1798.—Reinhold (Johann Christoph Leopold), while Bachelor of Medicine in Magdeburg, tendered for his theses, on the 16th of December 1797 and on the 11th of March 1798, two Latin dissertations on galvanism, one of which was offered concurrently with J. William Schlegel, then a medical student.

Numerous extracts from both the above very important papers, which treat extensively of galvanic experiments upon animals, vegetables, metals, etc., will be found at pp. 123–195, Vol. I of Sue's "Histoire du Galvanisme," Paris, 1802. Both dissertations review galvanism from its origin and make mention of many works which had not up to that time appeared in print.

In the first volume of his "Elements of Galvanism," London, 1804, Mr. C. H. Wilkinson devotes the entire Chap. VIII (pp. 188–260) to Reinhold's able review of galvanism, wherein are first cited Gardiner (author of "Observations on the Animal Economy"), Lughi, Klugel and Gardini as "anterior to the discovery of the

doctrine of animal electricity." Then follow accounts of their writings, as well as of those of Galvani and of Volta, "the Prince of Italian naturalists," after which due mention is made, in their proper order, of the observations of Aldini, Valli, Fontana, Berlinghieri, Monro, Fowler, Corradori, Robison, Cavallo, Wells, Havgk, Colsmann, Creve, Hermestædt, Klein, Pfaff, Ackermann, Humboldt (letters to Blumenbach, Crell, Pictet and M. de Mons), Eschenmeyer, Achard, Grapengieser, Gren, Michaelis, Caldani, Schmuck, Mezzini, Behrends, Giulio, Ludwig, Webster, Vasco, Hebenstreit and others.

The subject of the eighth and last section of Reinhold's Dissertations, as Wilkinson expresses it, consists of the exposition of the hypotheses of different authors on the galvanic fluid. These hypotheses he brings into two classes, as they relate to the seat which is assigned to the cause of the phenomena. The first of these classes belongs to the animal which is to be galvanized, and the second to the substance applied to its body, or to the arc. As the galvanic phenomena are ascribed by several physiologists to electricity, Reinhold makes a new division, relatively to the opinion of those who assert that the galvanic and electric fluids are the same, and of those who are persuaded that the former differs from the latter. Under the first head or division he ranges Galvani, Aldini, Valli, Carradori, Volta, in the early time of the discovery; then Schmuck, Voigt, and Hufeland; while under the second come Fowler and Humboldt. Of the latter division he makes subdivisions, in the first of which he comprehends Volta, Pfaff, Wells, Yelin and Monro, the second embracing Creve and Fabbroni. The other authors, not having openly avowed their opinion, he passes over in silence.

Reinhold is likewise the author of "Versuche um die eigentliche," etc. (Gilb. "Annal.," X, 1802, pp. 301–355), "Untersuchungen über die natur.," etc. (Gilb. "Annal.," X, 1802, pp. 450–481, and XII, 1803, pp. 34–48); "Galvanisch-elektrische Versuche," etc. (Gilb. "Annal.," XI, 1802, pp. 375–387); "Geschichte des Galvanismus," Leipzig, 1803; "Versuch einer skizzirten," etc. (Reil. "Archiv.," VIII, 1807–1808, pp. 305–354); "Ueber Davy's Versuche" (Gilb. "Annal.," XXVIII, 1808, pp. 484–485).

References.—Schlegel, "De Galvanismo"; Figuier, "Exp. et Hist. des Principales Découvertes," Vol. IV. pp. 310, 433; J. W. Ritter, "Beweis . . . in dem Thierreich . . ." Weimar, 1796; G. R. Treviranus, "Einfluss . . . thier, Reizbarkeit," Leipzig, 1801, and Gilbert's "Annalen," Vol. VIII for the latter year.

A.D. 1798.—Perkins (Benjamin D.), is given an English patent for a process enabling him to cure aches, pains and diseases in the human body by drawing electrified metals over the parts affected. His metallic tractors, originally introduced from America and

consisting of an alloy of different metals, awakened much curiosity both in England and on the Continent, and were successfully used by Dr. Haygarth and others, as related in the article "Somnambulism," of the "Encyclopædia Britannica."

In the Repert. II. ii. 179, it is said that one of the tractors was made of zinc, copper and gold, and the other of iron, platina and silver. M. V. Burq, in his "Métallo-thérapie," makes a review of the successful cures of nervous complaints effected by metallic applications.

References.—*Jour. de Phys.*, Vol. XLIX. p. 232; Mr. Langworthy, "View of the Perkinian Electricity," 1798; T. G. Fessenden, "Poetical petition against . . . the Perkinistic Institution . . ." London, 1803; B. D. Perkins, "The Influence of Metallic Tractors on the Human Body . . ." London, 1798–1799; "Bibl. Britan.," Vol. XXI, 1802, pp. 49–89; "Recherches sur le Perkinisme," etc. ("Annales. de la Soc. de Méd. de Montpellier," Vol. XXIX. p. 274); "Sur les tracteurs de Perkins" ("Mém. des Soc. Savantes et Lit.," Vol. II. p. 237); P. Sue, aîné, "Hist. du Galv.," IV. p. 286 and "Hist du Perkinisme," Paris, 1805; J. D. Reuss, "De re electrica," Vol. XII. p. 20; J. Krziwaneck, "De electricitate . . .," Prag., 1839.

A.D. 1798.—In a long letter written to Thomas Jefferson, President of the American Philosophical Society, and read before the latter body on the 4th of May 1798, the Rev. James Madison, then President of William and Mary College, details several experiments made by him to ascertain the effect of a magnet upon the Torricellian vacuum, and to explain the phenomena exhibited by magnets in proximity to iron filings.

He says: "Many ingenious men have supposed that the arrangement of the filings clearly indicated the passage of a magnetic fluid or effluvia in curved lines from one pole to another of a different denomination," but that the experiments which he relates prove the attractive force of the magnets, at either pole, to be the real cause of the phenomena which the filings exhibit, and that the action of the magnet upon the filings, when they approach within a certain distance, renders them magnetic. In every magnet, says he, there is at least one line, called the equator, from which, in the direction of both poles, the attractive power increases so that the filings will "incline toward them, forming angles which appear to be such as the resolution of two forces, one lateral and the other polar, would necessarily produce."

Thomas Jefferson, above named, succeeded Benjamin Franklin as United States Minister Plenipotentiary to Paris, 1784–1789, became Vice-President of the United States in 1796, and was sworn in as the successor of John Adams to the Presidency on the 4th of March 1801. The Rev. James Madison, D.D., second cousin of the fourth President of the United States bearing the same name,

became President of William and Mary College in 1777, and was consecrated first Bishop of Virginia by the Archbishop of Canterbury in Lambeth Palace, Sept. 19, 1790.

References.—"Transactions of the Am. Phil. Soc.," Vol. IV for 1799, O.S. No. 39, pp. 323–328.

A.D. 1798.—Monge (Gaspar), Comte de Peluse, a very able French scientist, called "the inventor of descriptive geometry," and from whom, it is said, that science received greater accessions than had before been given it since the days of Euclid and Archimedes, erects a telegraph upon the "Palais des Tuileries" in Paris. Of this, however, no reliable details are on record.

He also makes many experiments on the effects of optics and electricity, and, likewise, many useful observations on the production of water by inflammable air, independently of those carried on by Lord Cavendish.

References.—Biography in Charles Dupin's "Essai Historique," etc., and in "English Cycl.," Vol. IV. pp. 296, 297; Memoir at p. 175 of Vol. LV, *Phil. Mag.* for 1820; G. Monge, "Sur l'effet des étincelles . . ." Paris, 1786, and "Précis des leçons," Paris, 1805; *Sci. Am. Supp.*, No. 621, p. 9916, and the note at foot of p. 701 of "Fifth Dissert.," eighth ed. of "Encyclopædia Britannica," Vol. I; as well as "Mém. de l'Acad. des Sciences," 1786.

A.D. 1798.—Berton (Henri Montan), a prominent French composer and Professor of Harmony at the Paris "Conservatoire de Musique," also a member of the "Académie des Beaux-Arts," devises a novel electric telegraph which is merely alluded to, under the heading of "Note historique sur le télégraphe électrique," at p. 80 of the seventh volume of the *Comptes Rendus* for July 1838, as well as in Julia Fontenelle's "Manuel de l'électricité."

A.D. 1799.—Fabbroni—Fabroni—(Giovanni Valentino M.), Professor of Chemistry at Florence, communicates to the *Journal de Physique* (9th series, Tome VI, Cahier de Brumaire, An. VIII), an amplification of his able memoir, "Sur l'action chimique," etc. ("Dell' azione chimica . . ."), which was first presented by him during 1792 to the Florentine Academy and duly analyzed by Brugnatelli in his "Giornale physico-medico." Therein is made the first known suggestion as to the chemical origin of voltaic electricity, inquiring whether the phenomenon of galvanism is not solely due to chemical affinities of which electricity may be one of the concomitant effects, and also ascribing the violent convulsions in a frog to a chemical change which is produced by the contact of one of the metals with some liquid matter on the animal's body, the latter decomposing and allowing its oxygen to combine with the metal.

References.—" Elogio . . . A. Lombardi " (" Mem. Soc. Ital.," Vol. XX); *Cornhill Magazine*, Vol. II for 1860, p. 68; " Biog. Univ.," Vol. XIII. p. 311; " Encycl. Met.," " Galvanism," Vol. IV. p. 215; *Journal de Physique*, Vol. XLIX. p. 348; " Chambers' Ency.," 1868, Vol. IV. p. 593; " Mem. Soc. Ital.," Vol. XX. pp. 1 and 26; P. Sue, aîné, " Histoire du Galvanisme," Paris, An. X–1802, Vol. I. pp. 229–232; *Phil. Mag.*, Vol. V. p. 270; *Nicholson's Journal*, quarto, Vol. IV. p. 120; Sir Humphry Davy, " Bakerian Lectures," London, 1840, p. 49; Young's " Lectures," Vol. I. p. 752; W. Sturgeon, " Scientific Researches," Bury, 1850, p. 156; " Giornale di fisica " for 1810; " Giornale dell' Ital. Lettera . . ." IX. p. 97; " Atti della Reg. Soc. Economica di Firenze," XX. p. 26; Brugnatelli, *Annali di chimica*, II. p. 316 and XXI. p. 277; C. Henri Boissier, " Mémoire sur la décomp. de l'eau, etc.," Paris, 1801 (*Journal de Physique*, Prairial, An. IX).

A.D. 1799.—Jadelot (J. F. N.), French physician, translates Humboldt's work on " Galvanism," wherein he reviews the investigations of the great German scientist and treats of the application of the Galvanic fluid in medical practice. The observations of a friend of Humboldt, Dr. C. J. C. Grapengieser, are especially detailed and a complete account is given of all the noted physicians who have recorded experiments in the same line.

References.—For the medical applications of Galvanism: *Journal de Physique*, Vol. LII. pp. 391, 467; Gilbert's " Annalen," XI. 354, 488 and XII. 230, 450; " An. of Sc. Disc." for 1865, p. 123; Larrey, 1793, 1840; L. Desmortiers, 1801; Legrave, 1803; F. J. Double, 1803; J. Nauche, 1803; " Galv. Soc." (*Phil. Mag.*, Vol. XV. p. 281); Laverine, 1803; Mongiardini and Lando, 1803; F. Rossi, 1803–1827; J. Schaub, 1802–1805; B. Burkhardt, 1802; M. Butet, 1801; J. Le Roy d'Etiolle, " Sur l'emploi du Galv. . . ."; P. L. Geiger, 1802–1803; J. D. Reuss in " De Re Electrica "; M. Buccio, 1812; La Beaume, 1820–1848; P. A. Castberg (Sue, " Hist. du Galv.," IV. 264); Fabré-Palaprat and La Beaume, 1828; Rafn's " Nyt. Bibl.," IV; C. C. Person, 1830–1853; S. G. Marianini, 1841; C. Usiglio, 1844; F. Hollick, 1847; G. Stambio, 1847; Du Fresnel, 1847; H. de Lacy, 1849; M. Récamier, J. Massé, 1851; R. M. Lawrance, Robt. Barnes, and Crimotel de Tolloy, 1853; M. Middeldorpf, 1854; R. Remak, 1856, 1860, 1865; J. Seiler, 1860; V. Von Bruns, 1870.

A.D. 1799.—Humboldt (Friedrich Heinrich Alexander, Baron Von) (1769–1859), native of Berlin, is the author of " Cosmos " so frequently alluded to in these pages, and, in the words of one of his biographers, " will be remembered in future times as perhaps, all in all, the greatest descriptive naturalist of his age, the man whose observations have been most numerous and of the widest range, and the creator of several new branches of natural sciences."

The French translation of his work on " Galvanism " (" Expériences sur le Galvanisme . . . traduit de l'allemand par J. F. N. Jadelot ") appeared in Paris during the year 1799, before which date, Noad remarks, no one had applied the galvanic arc, as he did, to so many animals in various parts of their bodies. Among other results, he discovered the action of the electric current upon the pulsation of

the heart, the secretions from wounds, etc., and he proved upon himself that its action was not limited to the sole instants of the commencement and end of its passage.

In the first volume of his very interesting work on "Galvanism" (pp. 166–174, 261–310, 407–434) Wilkinson reviews the above-named publication which M. Vassalli-Eandi, in 1799, pronounced "the most complete that has hitherto appeared." The following sectional extracts are mainly taken from Mr. Wilkinson's book, Chap. IX. part ii. Humboldt's first experiments were made with the aid of M. Venturi, Professor of Natural Philosophy at Modena, and they were followed quite assiduously for a while, but it was not until he learned of the important observations made by Fowler, Hunter and Pfaff on animal electricity and irritability, that he was spurred on to still further extended investigations, which were carried on more particularly in presence of Jurine, Pictet, Scarpa, Tralles and Volta. Humboldt's work is divided into ten sections, as follows :

Sect. I treats of the relation between galvanic irritation and incitability.

Sect. II deals with the galvanic irritation produced without a coating, or metallic or charcoal substances (repeating the investigations of M. Cotugno, which led to the experiments of Vassalli during 1789).

Sect. III treats of the excitement produced by a simple metallic substance, or by homogeneous metallic parts (detailing the experiments of Aldini, Galvani, Berlinghieri, Lind, Pfaff and Volta).

Sect. IV discourses on heterogeneous metals. During his experiments in this line, which were aided by his elder brother, chance led him to a very interesting discovery. He found that the coatings of the nerve and muscle being homogeneous, the contractions may be produced when the degree of excitability is extremely feeble, provided the coatings of this nature are united by exciting substances, among which there is a heterogeneous one, having one of its surfaces covered by a fluid in a state of vapour. This observation, which was originally made at the commencement of 1796, surprised Humboldt so much that he instantly communicated it to Sömmering, Blumenbach, Hertz and Goethe. He had not as yet found recorded in the published works on galvanism any experiment the result of which had the smallest analogy with his discovery; and it was not until after the publication of the works of Pfaff on animal electricity that he became acquainted with any one similar to his own. There were, however, some differences, as he proves by several passages cited from the above author.

Sect. V relates to the classification of active substances into *exciters* and *conductors* of the galvanic fluid.

Sect. VI treats of experiments on the comparative effects of animal and vegetable substances employed in the galvanic chain.

Sect. VII describes, in a tabular form, the conducting substances, and those by which the galvanic fluid is insulated. In the employment of very long conductors, it was not possible for Humboldt to remark any interval between the instant when the muscle contracts and the moment the contact of the conductor takes place, the muscle and nerve being from two hundred to three hundred feet distant from each other. This announces a celerity of twelve hundred feet per second. The effect would be the same, should the conductors even be from ten thousand to twenty thousand feet in length. Thus Haller, in his physiology, ascribes to the nervous fluid a swiftness sufficient to enable it to run over a space of nine thousand feet a second. The calculation of Sauvages is carried to thirty-two thousand four hundred feet in the same space of time; and what is still infinitely more surprising, its celerity is estimated by the author of the essays on the mechanism of the muscles at five hundred and seventy-six millions of feet (upward of one hundred thousand miles) in the above space of a second of time. It ought here to be noticed that the great differences in these calculations arise from the different kinds of experiments on which they are founded.

Sect. VIII proves that the nerve which is intended to excite contractions in a muscle should be organically united with it, and it deals with the effects of galvanism upon vegetables, aquatic worms, insects and fishes.

Sect. IX describes the effects of galvanism upon amphibious animals, referring to the observations of Nollet, Rosel, Haller, Spallanzani, P. Michaelis and Herembstads.

Sect. X treats of the all-important effects of galvanism upon man, and makes allusion to the experiments of Hunter, Pfaff, Fowler, Munro, Robison, Hecker, Carradori, Achard, Grapengieser, Schmuck, Ludwig, Creve, Webster and Volta. In speaking of the observations made by the last named upon the tongue, he observes that some idea of them had been given thirty years before, in Sulzer's work entitled "The New Theory of Pleasures," published in 1767; and that if, at the above period, the consideration of the superficial situation of the nerves of the tongue had led to the artificial discovery of a nerve, the important discovery of metallic irritation would have been made in the time of Haller, Franklin, Trembley, Camper, and Buffon. How great a progress would not this revelation have made if the above philosophers had transmitted to us, thirty years ago, the theory and experiments which we leave to our successors?

Volta having singled out the differences, in point of savour, which result from galvanic experiments on the tongue according to the nature and disposition of the coatings, Humboldt repeated these experiments and added to them several of his own, with a nearly similar result. His different trials, however, having failed to produce any contraction of the tongue, appear to have established the truth of the ancient assertion of Galen, confirmed by Scarpa, namely, that the nerve with which the tongue is supplied by the third branch of the fifth pair is exclusively devoted to the sense of tasting, and that the ninth pair are exclusively destined for the motion of the tongue. This has been evidently proved by the galvanic experiments on the nerve in question.

The termination, in the pituitous membrane, of the nerves belonging to the organ of smelling, which originate in the first pair and in the first two branches of the fifth, together with the observation of the innumerable phenomena of sympathy between the organs of sight and those of smell and taste, had led to a presumption that, by galvanizing the nostrils, the smell would be affected. This supposition has not, however, been confirmed by any experiment.

The eleventh chapter of Wilkinson's work contains the analysis of the report drawn up by Mr. J. N. Hallé in behalf of the commission appointed by the French National Institute. This commission, which was organized to look into (*examiner et vérifier*) the different galvanic experiments which had been made and to ascertain their effects and results, was composed of such distinguished French physiologists as Coulomb, Fourcroy, Vauquelin, Charles, Sabathier, Halle, Pelletan and Guyton de Morveau, who were afterward joined by both Humboldt and the celebrated Prof. Venturi, of Modena.

Humboldt's observations respecting the application of galvanism to medicine are embodied in his well-known letter to M. Loder, inserted in "La Bibliothèque Germanique," Vol. IV, Messidor, An. VIII. p. 301, and are likewise detailed by Wilkinson (Chap. XIII) where references are made, more particularly, to the experiments of Hufeland, Behrends, Creve, Hymly, Pfaff and Anschell.

Between the years 1799 and 1804 Von Humboldt made observations upon the magnetic intensity of the earth, of which an account will be found in Vol. XV of the *Annalen der Physik*. These were made upon the American Continent during the course of his well-known journey, the equal of which latter, says Petersen, has not been seen since the days when Alexander the Great fitted out an extensive scientific expedition for Aristotle.

Humboldt's observations in the same line were continued for many years, notably between 1805 and 1806, in company with

Gay-Lussac during a tour which they made together through France, Switzerland, Italy and Germany, as related in the first volume of the *Mémoires de la Société d'Arcueil.*

Some idea can be formed of the extent of Humboldt's share in the magnetical labours of the first half of the century by perusing the last chapters of his "Cosmos" and the third volume of his "Relation Historique." At p. 615 of the last-named work, he himself says: "The observations on the variation of terrestrial magnetism, to which I have devoted myself for thirty-two years, by means of instruments which admit of comparison with one another, in America, Europe and Asia, embrace an area extending over 188 degrees of longitude from the frontier of Chinese Dzoungarie to the West of the South Sea, bathing the coasts of Mexico and Peru, and reaching from 60 degrees North latitude to 12 degrees South latitude. I regard the discovery of the law of the decrement of magnetic force from the pole to the equator as the most important result of my American voyage."

Humboldt was the first who made especial observations of those irregular perturbations to which he applied the name of "magnetic-storms," and the effects of which he originally observed at Berlin in 1806. These are treated of in his "Cosmos," London, 1858, Vol. V. pp. 135, etc., wherein he states that, when the ordinary horary movement of the needle is interrupted by a magnetic storm, the perturbation manifests itself often simultaneously, in the strictest sense of the word, over land and sea, covering hundreds and thousands of miles, or propagates itself gradually, in short intervals of time, in every direction over the earth's surface. In this same work ("Cosmos," Sabine's translation, Vol. I. p. 180), he contributes a graphic description of the concurrent and successive phases of a complete aurora borealis, reference to which is made by Noad ("Manual," etc., pp. 228, 229, 235), who, likewise, gives (pp. 612–615) an account of the establishment of magnetic stations at different points, for simultaneous observations, upon a plan originally laid out by Humboldt.

As early as 1806, this great naturalist had published at Erfurt his "Inquiry Concerning Electrical Fishes." While at Naples with Gay-Lussac, during the previous year, they had examined the properties of the *torpedo,* and had observed more particularly that the animal must be irritated previous to the shock, preceding which latter a convulsive movement of the pectoral fins is noticeable, and that electrical action is prevented by the least injury done to the brain of the fish; also, that a person accustomed to electrical discharges could with difficulty support the shock of a vigorous torpedo only fourteen inches long; that the discharge can be felt

with a single finger placed upon the electrical organs, and that an insulated person will not receive the shock if the fish is touched with a key or other conducting body (*Phil. Mag.*, Vol. XXII. p. 356; *Annales de Chimie*, No. 166; "Encycl. Brit.," 1855, Vol. VIII. p. 573). Humboldt's account of the mode of capturing gymnoti is detailed at pp. 575, 576 of the last-named work, as well as at pp. 472–474 of Noad's "Manual of Electricity," London, 1859.

At request of the King of Prussia, Humboldt returned from Paris to his native city in 1827, and it was during the winter of 1827–1828 that he began in Berlin his lectures on "Cosmos, or Physical Universe." This is the title of his chief work, which has universally been recognized one of the greatest productions ever published, and one which Ritter pronounced as being the culminating point both in the history of science and in the annals of civilization.

References.—Klenke, "Alex. Von. Humboldt, ein biographisches Denkmal," 1851: "Alex. Von. Humboldt . . . von Wittwer," Leipzig, 1861; "Life of Alex. Von Humboldt," translated by J. and C. Lassell, 2 Vols., London, 1873; "Meyer's Konversations-Lexikon," Leipzig und Wien, 1895, Vol. IX. pp. 44–47; Delambre's eulogium on Humboldt will be found at p. 15, Vol. XV of "Edinburgh Review"; Gren's "Neues Journal der Physik," Vol. IV; *Annales de Chimie*, Vol. XXII; *An. Chim. et Physique*, Vol. XI; Poggendorff's "Annalen," Vols. XV, XXXVII; "Société Philomathique," Tome I. p. 92; "Opus. Scelti," XXI. p. 126; Knight's "Mech. Dict.," Vol. II. p. 1874; *Phil. Mag.*, Vol. VI (1800), pp. 246, 250; "Cat. of Sc. Papers of Roy. Soc.," Vol. III. pp. 462–467; Vol. VI. p. 692; Vol. VII. pp. 1035–1036; *Sc. Am. Supp.*, No. 457, pp. 7301, 7302; Noad, "Manual," pp. 425, 528, 529, 612; Harris, "Rudim. Magn.," Part III. p. 103; Walker, "Ter. and Cos. Magn.," 1866, p. 81; Humboldt, "Aphorismi ex doctrina . . ." 1793; "Voyage, etc., dans les années, 1799–1804"; "Report of Seventh Meeting of British Association," Vol. VI, London, 1838, pp. 1, 5 and 7, and the remainder of Major Sabine's able article upon "Magnetic Intensity," in the same volume; "Report of the Meeting of the French Academy of Sciences" of May 21, 1849, for extract of a letter from Emile H. Du Bois-Reymond, sent by Humboldt, and treating of the Electricity of the Human Frame ("L'Institut," Mai 23, 1849); S. H. Christie and Sir G. B. Airy, "Report upon a Letter . . ." London, 1836; C. H. Pfaff, "Mém. sur les expér. de Humboldt . . ." 1799; Houzeau et Lancaster, "Bibl. Gén.," Vol. II. pp. 168, 1580–1581.

A.D. 1800.—William Nicholson, editor of the journal bearing his name, as well as an able chemist, and Sir Anthony (then Mr.) Carlisle, an English surgeon, while carrying on a series of chemical experiments, discover that, by means of the voltaic pile, water is decomposed into its constituents of oxygen and hydrogen. Their pile consisted of seventeen silver half-crown pieces alternated with equal discs of copper and cloth soaked in a weak solution of ordinary salt, and, having used a little water to make good the contact of the conducting wire with a plate to which the electricity was to be transmitted, Carlisle observed that gas was being set free in the

water, while Nicholson recognized the odour of hydrogen proceeding from it. The better to observe this result they afterward (May 2, 1800) employed a small glass tube, which, after being filled with water, was stopped at both ends with corks through which passed two brass wires extending a little distance into the water. When platinum wires were used, gas bubbles appeared from both wires, and the two gases, hydrogen from the negative and oxygen from the positive end, were found to be nearly in the proportion to constitute water. (See account of above in Pepper's "Electricity," p. 312, as well as at pp. 193 and 194 of Fahie's "History of Telegraphy to 1837," and at pp. 339 and 340 of Vol. I of Lardner's "Lectures.")

During the year 1781 William Nicholson had published the first edition of "An Introduction to Natural Philosophy." In the second section of the third book of the latter work he treats of magnetism, the methods of communicating it, and the variation of the compass. The loadstone, he says, "is a ponderous ore of iron, usually of a dirty black colour and hard enough to emit sparks with steel. It is found in most parts of the world, and possesses a natural magnetism acquired most probably from its situation or position with respect to the earth." In the third section of the same third book he discourses upon electrical matter, electrical jars, electrical instruments, and devotes much space to the explanation of experiments and facts touching natural and atmospheric electricity, balls of fire, of the *ignis fatuus*, or *will-with-the-wisp*, of waterspouts, earthquakes, etc., alluding to most of the then well-known observations thereon recorded by different scientists.

To Nicholson is due the invention of a revolving doubler, an improvement upon that of Abraham Bennet, which is described and illustrated in the "Encyclopædia Britannica," as well as in No. 647, p. 10327, of the *Sci. Am. Supplement* (Read at A.D. 1794, also *Phil. Trans.*, Vol. LXXVIII. p. 1, for M. Cavallo's remarks upon the defects in Bennet's doubler).

The above-named discovery of Nicholson and Carlisle, which, Mr. Davy says (*Phil. Trans.* for 1826, p. 386) was the true origin of all that had been previously done in electro-chemical science, together with Hisinger and Berzelius' decomposition of salts, and the successful decomposition of ammonia, nitric acid, etc., made by the distinguished English chemical philosopher, Dr. William Henry (*Nicholson's Journal*, Vol. IV. pp. 30, 209, 223 and 245; "Encyclopædia Metropolitana," Vol. IV. pp. 221 and 611; Hutton's abridgment of *Phil. Trans.*, Vol. X. pp. 505, 599), as well as Davy's decomposition of the earths and alkalies, creates at the commencement of another century, as we have already observed, an entirely new epoch in the history of chemistry.

References.—Nicholson's letter to the Royal Society, read June 5, 1788, entitled "A description of an instrument which, by the turning of a winch, produces the two states of electricity without friction or communication with the earth" (influence or induction machine !); *Nicholson's Journal*, 1800, Vol. IV. p. 179; Despretz, "Physique," 1827, p. 432; *Mechanics' Magazine*, Nov. 9, 1839; biography in "English Cyclopedia," Vol. II. p. 82; Tomlinson, "Cyclopedia of Arts," etc., 1862, Vol. I. p. 566; "Memoir of Joseph Henry," 1880, p. 78; Highton, "The Electric Telegraph," p. 28; Noad, "Manual," p. 353; "Encycl. Brit.," 1855, Vol. XXI. p. 628; *Phil. Trans.*, Vol. LXXIX. p. 265; *Philosophical Magazine*, Vol. VII. p. 337, and XLV. p. 396; C. H. Wilkinson, "Elements of Galvanism," 1804, Vol. II. pp. 21, 22, 46, 68, 375, etc.; "Bibl. Brit.," Vol. XIX. p. 274; "Sciences et Arts," Part I. p. 274, and Part II. p. 339, for Volta's answer to Nicholson. For various treatises on, and methods of, effecting the decomposition of water, consult Adam W. Von. Hauch (*Mons' Jour. de Chimie*, Vol. I. p. 109); G. Carradori (*Journal de Physique*, An. XII. p. 20, "Nuova Scel. d'Op.," quarto, Vol. I. p. 29, Paris and Milan, 1804); W. Wilson (*Phil. Mag.*, Vol. XXII. p. 260); Cioni e Petrini (Brugnatelli's *An. di Chim.*, Vol. II. p. 322, 1805); M. Van Marum's letter to Nauche (*Jour. du Galvan.*, Eleventh Book, p. 187; *Gilb. Ann.*, XI. p. 220); J. C. I. A. Creve, as at Ronalds' "Catalogue," p. 119; "Bibl. Britan.," An. VIII. vol. xv. p. 23 and An. IX. vol. xvi. p. 23; J. C. Cuthbertson (*Phil. Mag.*, Vol. XXIV. p. 170, 1806); Jos. Mollet's Memoirs published at Aix and Lyons, 1821, 1823, as well as in the Reports of the Lyons Academy, 1823, 1825, and in the *Comptes Rendus* for 1823; Mr. Leeson (*Sturgeon's Annals*, Vol. IV. p. 238, 1839; Robert Hare, *Trans. Am. Phil. Soc.*, N.S., Vol. VI. p. 339; L. Palmieri and P. Linari-Santi, "Telluro-Elettricismo," 1844; M. Merget's theses, read before the Paris Academy, Aug. 30, 1849; A. Connel, *Phil. Mag.*, 4th Ser., for June 1854, p. 426); Dr. Edward Ash, "On the action of Metals . . . upon water," in letter to Humboldt, April 10, 1796.

A.D. 1800.—Grout (Jonathan, Jr.), of Belchertown, Mass., takes out, October 24, the first telegraph patent in the United States. It was for a contrivance which he operated between Martha's Vineyard and Boston, about ninety miles' distance, from hilltop to hilltop, and which was sighted by telescopes ("Telegraph in America," J. D. Reid, 1887, p. 5; also "Growth of Industrial Art," Washington, 1888, p. 55).

A.D. 1800.—Cruikshanks (William), of Woolwich, England, confirms Nicholson and Carlisle's experiments, and, in his further prosecution of them, employs a pile consisting of from forty to a hundred pairs of zinc and silver plates, as well as a tube holding silver terminals or electrodes, in place of the platinum electrodes, which they were first to make use of.

He discovers that hydrogen is always evolved from the silver or copper end of the voltaic pile and oxygen from the other; that, under like circumstances, metals can be "completely revived" from their solutions; that pure oxygen is freed when a wire of non-oxidable metal, like gold, is connected with the zinc plate, and that fluids that contain no oxygen cannot transmit the voltaic current.

These results were verified by Lieut. Col. Henry Haldane, whose many observations upon the series of metals best suited to the production of voltaic electricity and their respective powers in connection therewith are related at pp. 242 and 313, Vol. IV of *Nicholson's Journal* for Sept. and Oct. 1800.

Cruikshanks was also the first to discover, in 1800, that when passing the electric current through water tinged with lithmus, the wire connected with the zinc end of the pile imparted a red tinge to the fluid contiguous to it, and that by using water coloured with Brazil wood, the wire connected with the silver end of the pile produced a deeper shade of colour in the surrounding fluid, whence it appeared that an acid was formed in the former case, and an alkali in the latter. Fahie, who thus mentions the fact, justly remarks that upon this discovery are dependent the electro-chemical telegraphs proposed by Bakewell, Caselli, Bonelli, D'Arlincourt, Sawyer and others.

Cruikshanks is the inventor of the galvanic trough, an improvement upon the voltaic pile, made by soldering together rectangular plates of zinc and copper, and so arranging them horizontally, in a box of baked wood coated with an insulating substance, as to allow of open spaces which can be filled with a solution of salt and water or with diluted acid, to take the place of the wet plates of cloth, paper or pasteboard. Cruikshanks' plan was adopted in the construction of the powerful battery of 600 pairs, which Napoleon Bonaparte presented to the Ecole Polytechnique and upon which Gay-Lussac and Thénard made their important experiments during the year 1808. As Noad remarks, it is a very convenient form when sulphate of copper is used, for Dr. Fyfe has shown (*Phil. Mag.*, Vol. XI. p. 145) that this exciting agent increases the electro-chemical intensity of the electric current as compared with that evolved by dilute sulphuric acid in the proportion of 72 to 16.

Both the above and Volta's form of battery were much improved upon by Dr. William Babington (1756–1833), who united the pairs of zinc and copper plates by soldering them at one point, and by attaching them to a strip of wood in such a manner as to allow of the entire line being immersed at will into an earthenware or wooden trough having a corresponding number of cells or partitions. The extraordinarily strong voltaic battery, constructed in 1808 for the Royal Institution of London, by Mr. Eastwick under the direction of Sir Humphry Davy and of John George Children, was built upon this plan. It consisted of 200 separate parts, each part being composed of ten double plates, in all 2000 double plates of zinc and copper with a total surface of 128,000 square inches, and the charge which William H. Pepys was accustomed to give it consisted of a

mixture of 1168 parts of water, 108 parts nitrous acid, and 25 parts sulphuric acid.

REFERENCES.—Wilkinson, "Elements of Galvanism," 1804, Vol. II. pp. 52–63, 96–99; Pepper, "Electricity," 1809, pp. 313–315; Noad, "Manual," pp. 263, 264; Tomlinson, "Cyclopædia of Arts," Vol. I. p. 566; Napier, "Electro-Metallurgy," 1853, pp. 27, 28; *Nicholson's Journal*, Vol. IV. pp. 187, 254, 261 and 511; *Sturgeon's Annals*, Vol. IX. p. 309; Cruikshanks, "Some Experiments and Observations on Galvanic Electricity," July 1800; also "Additional Remarks on Galvanic Electricity," September 1800.

A.D. 1801.—Davy (Humphry), a very eminent English chemical philosopher, whose early studies had been greatly influenced both by Dr. John Tonkin, of Penzance, and by Gregory Watt, son of the celebrated inventor, James Watt, as well as by Mr. Davies Giddy Gilbert, who brought him to the notice of the English Royal Institution, delivers before the latter body, on the 25th of April 1801, his first lecture, wherein he traces the history of galvanism, and describes the different methods of "accumulating" it.

His first communication to the Royal Society was made in June of the same year, and is entitled, "An Account of Some Galvanic Combinations Formed by the Arrangement of Single Metallic Plates and Fluids, Analogous to the New Galvanic Apparatus of Volta." As his able biographer, Prof. T. James Stewart Traill, M.D., of Edinburgh, remarks, this paper is the first of that series of electro-chemical investigations which have immortalized his name. In all hitherto constructed piles, the series had consisted of not less than two metals, or of one plate of metal, another of charcoal, and some interposed fluid. He showed in this paper that the usual galvanic phenomena might be energetically exhibited by a single metallic plate and two strata of different fluids, or that a battery might be constructed of one metal and two fluids, provided one of the fluids was capable of causing oxidation on one of the surfaces of the metal ("Bakerian Lectures," London, 1840, pp. 32, etc., and *Phil. Trans.*, Vol. XCI. p. 297).

On the 20th of November 1806 was read before the Royal Society Davy's first Bakerian lecture, "On Some Chemical Agencies of Electricity." This essay was universally regarded as one of the most valuable contributions thus far made to chemistry, and obtained for Davy the prize founded by Napoleon when First Consul, to be awarded by the French Institute, "à celui, qui par ses expériences et ses découvertes, fera faire a l'électricité et au galvanisme un pas comparable à celui qu'ont fait faire à ces sciences Franklin et Volta" ("Bakerian Lectures," 1840, p. 56, and notes at p. 349, Vol. I of Dr. Lardner's "Lectures," etc., 1859).

Of the French Institute Davy became a member in 1817.

Regarding the above-named important paper, given in full at pp. 1–56, of the volume of "Bakerian Lectures," already referred to, Davy says (*Phil. Trans.* for 1826, p. 389): "Referring to my experiments of 1800, 1801 and 1802, and to a number of new facts, which showed that inflammable substances and oxygen, alkalies and acids, and oxidable and noble metals, were in electrical relations of positive and negative, I drew the conclusion *that the combinations and decompositions by electricity were referable to the law of electrical attractions and repulsions*," and advanced the hypothesis "*that chemical and electrical attractions were produced by the same cause, acting in the one case on particles; in the other on masses; . . . and that the same property, under different modifications, was the cause of all the phenomena exhibited by different voltaic combinations*" (Vol. I. pp. 678–684 of Dr. Thomas Young's "Course of Lectures," London, 1807, on "Electricity in Motion," also Dr. Henry M. Noad's "Manual," London, 1859, pp. 362–365).

The second Bakerian lecture, "On some new phenomena of chemical changes produced by electricity, particularly the decomposition of the fixed alkalies, and the exhibition of the new substances which constitute their bases; and on the general nature of alkaline bodies," was read Nov. 19, 1807. In this he gives an account of the most brilliant of all his discoveries (made during the previous month), proving that the so-called fixed alkalies are merely combinations of oxygen with metals. It has been stated by Dr. John Ayrton Paris that since the days of Newton no such happy and successful instance of philosophical induction has ever been afforded as that by which Davy reached the above-named results (*Phil. Trans.* for 1808, Vol. XCVIII. pp. 1–44). Davy's observations were fully confirmed by Gay-Lussac, Thénard, Berzelius and Pontin (*Annales de Chimie*, Vol. LXXII. p. 193; Vol. LXXV. pp. 256–291; *Bibl. Brit.* for June 1809, p. 122). Although Davy was less successful in his attempt to decompose the proper earths, he proved that they consist of bases united to oxygen. It was reserved for Friedrich Wöhler, Berzelius and Bussy to exhibit the bases by themselves, and to show that all, excepting silica, are metallic, and capable of uniting with iron.

It is said that the original 500-plate batteries of the Royal Institution were so worn in the course of Davy's experiments as to be almost unserviceable, and that he suggested to the managers the propriety of starting a subscription for the purchase of a large galvanic battery. This being acted upon during the month of July 1808, he was placed in possession of the battery already alluded to in the Cruikshanks article (A.D. 1800), and which was the most powerful constructed up to that time. "With this battery Davy

did not reach any new results of importance; but he was enabled to demonstrate the galvanic phenomena upon a more brilliant scale. Nor was the increased power necessary to carry on successfully the experiments on the decomposition of the alkalies and the earths as was apparently believed by many of those historians of science. . . . who attributed the author's brilliant success in electro-chemical research to his supposed extraordinary means, the enormous voltaic batteries of the Royal Institution." In this connection, the terse notes appearing at foot of pp. 62, 63, 106, 107 of the 1840 edition of the "Bakerian Lectures" will prove interesting reading.

It was with the afore-named galvanic combination that Davy openly made—in 1809–1810, and not in 1813, as has been frequently stated—the first display of the continuous electric arc (John Davy, "Memoirs of the Life of Sir Humphry Davy," p. 446).

"When the cells of this battery were filled with sixty parts of water mixed with one part of nitric acid and one part of sulphuric acid," he says, "they afforded a series of brilliant and impressive effects. When pieces of charcoal about an inch long and one-sixth of an inch in diameter were brought near each other (within the thirtieth or fortieth part of an inch), a bright spark was produced, and more than half the volume of the charcoal became ignited to whiteness, and by withdrawing the points from each other a constant discharge took place through the heated air, in a space equal at least to four inches, producing a most brilliant ascending arch of light, broad and conical in form in the middle. When any substance was introduced into this arch, it instantly became ignited; platina melted as readily in it as wax in the flame of a common candle; quartz, the sapphire, magnesia, lime, all entered into fusion; fragments of diamond, and points of charcoal and plumbago, rapidly disappeared, and seemed to evaporate in it, even when the connection was made in a receiver exhausted by the air pump; but there was no evidence of their having previously undergone fusion" ("Elements of Chemical Philosophy," 1812, p. 154).

Dr. Paris says that Davy had already produced the spark upon a small scale as far back as 1800 (*Nicholson's Journal*, Vol. III, quarto, p. 150), and we learn, through an article published upon the early experiments with the electric light, the names of others who had likewise noticed the arc at about the same period, while Quetelet informs us that M. Curtet is reported to have observed the light between carbon points during the year 1802 (Curtet's letter to J. B. Van Mons in the latter's *Journal de Chimie*, No. VI. p. 272, and in *Journal de Physique*, An. XI. p. 54). The article referred to is as follows:

"Dr. S. P. Thompson has given the following interesting details in regard to this subject: In looking over an old volume of the *Journal de Paris*, I found, under date of the Twenty-second Ventose, An. X (March 12, 1802), this passage, which evidently refers to an exhibition of the electric arc: 'Citizen (E. G.) Robertson, the inventor of the phantasmagoria (magic lantern), is at present performing some interesting experiments that must doubtless advance our knowledge concerning galvanism. He has just mounted metallic piles to the number of 2500 zinc plates and as many of rosette copper. We shall forthwith speak of his results, as well as of a new experiment that he performed yesterday with two glowing carbons. The first having been placed at the base of a column of 120 zinc and silver elements, and the second communicating with the apex of the pile, they gave at the moment they were united a brilliant spark of an extreme whiteness that was seen by the entire society. Citizen Robertson will repeat the experiment on the 25th.'"

The date generally given for this discovery by Humphry Davy is 1809, but earlier accounts of his experiments are found in Cuthbertson's "Electricity" (1807), and in several other works.

In the *Phil. Mag.*, Vol. IX. p. 219, under date of Feb. 1, 1801, in a memoir by Dr. H. Moyes, of Edinburgh, relative to experiments made with the pile, we find the following passage: "When the column in question had reached the height of its power, its sparks were seen by daylight, even when they were made to jump with a piece of carbon held in the hand." In the same volume of the *Phil. Mag.*, and immediately following Dr. Moyes' letter to Dr. Garthshore, on experiments with the voltaic pile, will be found an account of similar investigations made in Germany, and communicated by Dr. Frulander, of Berlin.

In the "Journal of the Royal Institution" (1802), Vol. I. p. 106, Davy describes a few experiments made with the pile, and says: "When instead of metals, pieces of well-calcined carbon were employed, the spark was still larger and of a clear white." On p. 214 he describes and figures an apparatus for taking the galvano-electric spark into fluid and aeriform substances. This apparatus consisted of a glass tube open at the top, and having at the side another tube through which passed a wire that terminated in a carbon. Another wire, likewise terminating in carbon, traversed the bottom, and was cemented in a vertical position.

But all these observations are subsequent to a letter printed in "Nicholson's Journal" for October 1800, p. 150, entitled "Additional experiments on Galvanic Electricity in a letter to Mr. Nicholson." The letter is dated Dowry Square, Hotwells, Sept. 22, 1800, and is signed by Humphry Davy, who at this epoch was assistant

to Dr. Beddoes at the Philosophical (Pneumatic) Institution of Bristol. It begins thus :

" Sir : The first experimenters in animal electricity remarked the property that well calcined carbon has of conducting ordinary galvanic action. I have found that this substance possesses the same properties as metallic bodies for the production of the spark when it is used for establishing a communication between the extremities of Signor Volta's pile.

Among the papers read by Davy before the Royal Society between June 30, 1808, and Feb. 13, 1814, are the following : " Electro-chemical researches on the decomposition of the earths, with observations on the metals obtained from the alkaline earths, and on the amalgam procured from ammonia " ; "An account of some new analytical researches on the nature of certain bodies," etc., and the Bakerian lecture " On some new electro-chemical researches, on various objects, particularly the metallic bodies from the alkalies and earths, and on some combinations of hydrogen " ; " Elements of chemical philosophy, detailing experiments on electricity in vegetation."

In alluding to the important subjects covered by him during the above-named period, his brother and biographer, John Davy, M.D., F.R.S., says : " I shall not attempt an analysis of these papers ; I shall give merely a sketch of the most important facts and discoveries which they contain, referring the chemical reader to the original for full satisfaction. After the extraction of metallic bases from the fixed alkalies, analogies of the strongest kind indicated that the alkaline earths are similarly constituted ; and he succeeded in proving this in a satisfactory manner. But, owing to various circumstances of peculiar properties, he was not able on his first attempts to obtain the metals of those earths in a tolerably pure and insulated state for the purpose of examination. On his return to the laboratory after his illness, this was one of the first undertakings. He accomplished it to a certain extent by uniting a process of Messrs. Berzelius and Pontin, who were then engaged in the same enquiry, with one of his own. By negatively electrifying the earths, slightly moistened, and mixed with red oxide of mercury, in contact with a globule of mercury, he obtained amalgams of their metallic bases ; and, by distillation, with peculiar precautions, he expelled the greater part of the mercury. Even now, in consequence of the very minute quantities of the bases which he procured, and their very powerful attraction for oxygen, he was only able to ascertain a few of their properties in a hasty manner. They were of silvery lustre, solid at ordinary temperatures, fixed at a red heat, and heavier than water. At a high temperature they

abstracted oxygen from the glass, and, at ordinary temperatures, from the atmosphere and water, the latter of which in consequence they decomposed. The names he proposed for them, and by which they have since been called, were barium, strontium, calcium and magnium, which latter he afterwards altered to magnesium. . . ."

The reviewer of Davy, in the columns of the "Chemical News," writing in 1879, states that his papers on numerous subjects flowed into the Royal Society's archives in an uninterrupted stream, and it may be said, without exaggeration, that his work, especially during the six years from 1806 to 1812, did more for chemistry than the 60 which followed them.

Between the last-named dates, Davy was asked by the Dublin Society to give a course of lectures on electro-chemical science, which he delivered Nov. 8–29, 1810. Trinity College afterward conferred on him the degree of LL.D., and he was knighted by the Prince Regent one day before resigning from the Royal Institution, wherein he gave his farewell address on April 9, 1812.

In 1813, accompanied by his bride and Mr. Faraday (his "assistant in experiments and in writing"), Davy made his first trip to the Continent, where he met Ampère, Humboldt, Gay-Lussac, Vauquelin, Cuvier, Laplace and other distinguished scientists, and where he carried on many experiments, of which the results were duly communicated to the Royal Society, as were also the observations made by him up to the time of the completion of his second trip in 1820.

Besides the Rumford medal conferred on him in 1816, he received a baronetcy two years later, and was given, in 1827, the medal of the Royal Society, the presidential chair of which he occupied for seven consecutive years.

One of the four memoirs produced by Davy in 1818–1829 treats of electromagnetism. In 1820, Davy, Arago and Seebeck independently discovered the magnetizing power of the electric current on steel and iron needles or filings. In Davy's experiments, it is said, the filings adhered to the wire connecting the poles of a voltaic apparatus, consisting of a hundred pairs of plates of four inches, in such considerable quantities as to form a mass around it ten or twelve times the thickness of the wire (*Phil. Trans.* for 1821, p. 9; *Annales de Chimie et de Physique*, Vol. XV. p. 93).

Davy was actively engaged during 1821–1822 in experiments on electromagnetism and on electricity in vacuo, reaching the conclusion, in the last-named channel, that electric light as well as electrical attractions and repulsions are observable in the most perfect vacuum obtainable. This is readily demonstrated with either the apparatus employed by Tyndall in his Lecture VIII,

"On the analogies of light, heat and sound," or with the apparatus used by Davy and illustrated at Plate CCXXIII of the "Encyclopædia Britannica," eighth edition. From the numerous experiments and observations recorded in the last-named work the following are extracted :

"A spark capable of passing through only half an inch in common air will pass through six inches of the Torricellian vacuum. . . . When the minutest quantity of rare air was introduced into the mercurial vacuum, the colour of the electric light changed from bright *green* to *sea green*, and by increasing the quantity, to *blue* and *purple*. At a low temperature the vacuum became a much better conductor. A vacuum above fused tin exhibited nearly the same phenomena. At temperatures below zero the light was yellow and of the palest phosphorescent kind, just visible in great darkness, and not increased by heat. When the vacuum was formed by pure olive oil and by chloride of antimony, the electric light through the vapour of the chloride was more brilliant than that through the vapour of the oil; and in the last it was more brilliant than in the vapour of mercury at common temperatures. The light was of a *pure white* with the chloride, and of a *red* inclining to *purple* in the oil. . . . In carbonic acid gas the light of the spark is white and brilliant, and in hydrogen gas it is red and faint. When the sparks are made to pass through balls of wood or ivory they are of a *crimson* colour. They are *yellow* when taken over powdered charcoal, *green* over the surface of silvered leather, and *purple* from imperfect conductors."

Davy's Bakerian lecture for 1826 was entitled "On the relation of electrical and chemical changes." Two years previous to its reading he had communicated to the English Government his discovery of what he erroneously considered a remedy against the rapid deterioration of copper sheathing for ships. His plan consisted in altering the electrical condition of the copper by adding plates of zinc or iron (called "protectors"), but the bottoms of the vessels became so foul through the deposition of calcareous matter and the adhesion of large balani and lepades, etc., to the copper, that the attempt had to be abandoned (A. Bobierre, "Thèse . . . pour doubler les navires," Nantes, 1858). It was in the same year (1824) that Davy made an important journey through Sweden, Norway, Denmark, Holstein, and Hanover, during which he met Oersted, Berzelius, Gauss, Olbers, Schumacher and other savants.

His last communication to the Royal Society, "Remarks on the Electricity of the *Torpedo*," was sent from Rome in 1828, one year before his death, and embodies the result of many observations made while on the Continent, more especially during the years

1814–1815. The investigations in this line which, owing to continued ill health, he was unable to carry on, were completed by his brother, Dr. John Davy, who established the following points of difference between the phenomena of the *torpedo* and those of other kinds of electricity :

" Compared with voltaic electricity, its effect on the multiplier is feeble : its power of decomposing water and metallic solutions is inconsiderable; but its power of giving a shock is great, and so also is its power of magnetizing iron. Compared with common electricity, it has a power of affecting the multiplier, which, under ordinary circumstances, common electricity does not exhibit; its chemical effects are more distinct; its power of magnetizing iron and giving a shock appears very similar; its power of passing through air is infinitely less as is also (if it possess it at all) the power of producing heat and light."

Davy likewise made noteworthy observations concerning the pyro-electricity of the tourmaline, confirming previous investigations in the same line, and asserting that " when the stone is of considerable size, flashes of light may be seen along its surface " (" Elements of Chemical Philosophy," Vol. I. p. 130), a curious fact which Sir David Brewster says he does not believe has ever been verified by any subsequent observer.

It is not within the scope of this " Bibliographical History " to describe Davy's other notable papers relative to the miner's safety lamp, etc., but reference should be made here to his first scientific memoir, " On heat, light and the combination of light " (Sir H. Davy's works, Vol. II) of which copious extracts are given by Prof. John Tyndall in the appendix to his third lecture on " Heat considered as a mode of motion."

As regards the caloric theory, which had deservedly been engaging the attention of so many scientists, it is, however, thought best to quote here from Deschanel's article on thermo-dynamics : " Strange to say, this theory survived the many exposures of its weakness and the, if possible, still more conclusive experiment of Sir Humphry Davy, who showed that two pieces of ice, when rubbed together, were converted into water, a change which involves not the evolution but the absorption of latent heat, and which cannot be explained by diminution of thermal capacity, since the specific heat of water is much greater than that of ice. Davy, like Rumford, maintained that heat consisted in motion, and the same view was maintained by Dr. Thomas Young; but the doctrine of caloric nevertheless continued to be generally adopted until about the year 1840, since which time the experiments of Joule, the eloquent advocacy of Meyer, and the mathematical deductions of Thomson,

Rankine and Clausius, have completely established the mechanical theory of heat, and built up an accurate science of thermodynamics."

References.—" The Life of Sir H. Davy," by John Ayrton Paris, M.D., 1831, and by T. E. Thorpe, New York, 1896, also his life by Dr. John Davy, F.R.S., 1836; and his biography and articles " Chemistry " and " Voltaic Electricity " in the " Encyclopædia Britannica "; " Works of Sir Humphry Davy," edited by John Davy, 1839–1840; " The Fragmentary Remains . . . of Sir H. Davy," 1858; " Dic. Tech. et Prat. d'Electricité " de Mr. Geo. Durant, Paris, 1887–1889; W. T. Brande, " Manual of Chemistry," London, 1848, Vol. I. pp. xciii–cv, 213–224; C. H. Wilkinson, " Elements of Galvanism," London, 1804, Vol. II. pp. 80–86, and Chap. XXVII; Thomas Thomson, " History of the Royal Society," London, 1812, pp. 454–455; " Galvanism," in Dr. Lardner's Lectures; Noad's " Lectures on Chemistry," pp. 32–33; Bakewell's " Elec. Sc.," pp. 33–35; Daniel Davis, " Manual of Magnetism," 1846–1852; Thomson, " History of Chemistry," Vol. II. pp. 260–261; " Elem. of Exp. Chem.," Wm. Henry, London, 1823, Vol. I. p. 192; " Elements of Chemical Philosophy," p. 155; Thomas Thomson, M.D., London, 1830; " Outline of the Sciences of Heat and Electricity," pp. 467, et. seq., 491–495, 533; De la Rive's " Treatise on Electricity . . ." Vol. II. pp. 282–283; " Encyclopedia Metropolitana," Vol. IV (Galv.), pp. 176, 178, 222, and (Elec. Mag.) pp. 9 and 10; Gay-Lussac and Thénard, *Phil. Mag.*, Vol. XXXII. p. 88, 1809; Jacquin, *Phil. Mag.*, Vol. XXXVI. p. 73, 1810; M. Donovan, *Phil. Mag.*, Vol. XXII. pp. 227, 245, 1811; M. Yatman, " A Letter . . ." and Davy's " Enquiries . . ." London, 1811, 1814; W. Henry, " On Sir H. Davy and Dr. Wollaston," London, 1830; Contessi G. Lelandri, " Ann. Reg. Lomb., Veneto," 11, 78, 1832, and F. I. Roux, " Conservation des plaques . . ." Paris, 1866; *Nicholson's Journal*, 4to, Vol. IV. pp. 275, 337 and 394; and 8vo., Vol. I. p. 144, Vol. III. p. 135; Dredge, " Electric Illumination," Vol. I. pp. 24, 25, 30; *Phil. Mag.*, Vol. VII. p. 347, for experiments of Dr. Henry Moyes, also Vol. XI. pp. 302, 326; XXVIII. pp. 3, 104, 220; XXIX. p. 372; XXXI. p. 3; XXXII. pp. 1, 18–22, 101, 146, 193; XXXIII. p. 479; XXXV. p. 401; XXXVI. pp. 17, 85, 352, 404; XL. p. 145; LVIII. pp. 43, 406; LIX. p. 468; LX. p. 179; *Phil. Mag. or Annals*, Vols. I. pp. 31, 94, 190; VI. p. 81; X. pp. 214, 379, 426; *Phil. Trans.* for 1801, 1809, 1810, 1822; Sturgeon's " Scientific Researches," Bury, 1850, pp. 14–16, 23; *Annales de Chimie*, Vol. XV. p. 113; " Société Philomathique," An. X. p. 111; Becquerel, Paris, 1850, Vol. I. pp. xi and 33 note; " Nuova Scelta d'Opusc." Vol. II. pp. 190, 282; " Beiträge zur Erweiterung," etc., Berlin, 1820; " Elemente d. Chemischen," etc., Berlin, 1814; " Royal Society Catalogue of Scientific Papers," London, 1868, Vol. II. pp. 171–175; " Biographie Générale," Vol. XIII. p. 264; " Engineering," London, Vol. LII. p. 759; " Abstracts of Papers . . . Roy. Soc.," London, 1832–1833, Vol. I. pp. 59, 247, 278, 313, 350; Vol. II. pp. 154, 159, 189, 213, 242, 281, 354; " Royal Society Catalogue of Scientific Papers," Vol. II. pp. 175–180, and Vol. VI. p. 633 (likewise Vol. VII. pp. 494–495—for John Davy); " Bibliothèque Britannique," Vol. XVII for 1801, pp. 237, 246; Vol. XXV, N.S. for 1824, p. 98; Vol. XXXIV, O.S. for 1807, p. 397 (the same as " Nicholson's Journal," for January 1807); Vol. XXXV. pp. 16, 141; " Edin. Phil. Journ.," Vol. X. p. 185.

Of the afore-named references in the *Phil. Magazine*, Vol. XXXI, that at p. 3 relates to Davy's new Eudiometer acting by the electric spark exactly in the same manner as that of Il Marchese de Brezé, described in the " Opuscoli."

A.D. 1801.—Flinders (Matthew), a very able navigator and captain in the English merchant service, sails in the bark "Investigator" for the purpose of circumnavigating and exploring New Holland. During this memorable voyage he carefully observed the cause of errors in the variation of the magnetic needle as depending on the direction in azimuth of the ship's head, having often noticed, as a writer in the English *Quarterly Review* expresses it (Vol. CXVIII. p. 343), that the direction of the compass needle frequently wandered from that which the known variation due to the geographical position of the ship assigned to it. To correct those disturbances he suggested placing aft of the compass a vertical bar of soft iron, whose upper end, having like magnetism as the imaginary mass in the ship's head, would, in acting on the opposite pole of the compass needle, rectify its disturbances.

Flinders had, during the year 1795, made observations in the same line as those recorded by the astronomer Bayly, who had sailed with Captain Cook during his last two voyages, but it was not until his return from the unfortunate first voyage above alluded to that he properly recorded his investigations for the benefit of navigators.

References.—"Encyclopædia Britannica," 1856, Vol. X. p. 295, and article "Australia," Vol. IV. pp. 253, 254; "English Cyclopædia" (Biography), Vol. II. pp. 933–935; *Sci. Am. Supp.*, No. 534, p. 8526; William Walker, "The Magnetism of Ships," London, 1833, pp. 21–23; "Abstracts of Papers of the *Phil. Trans.*, 1800–1830," p. 187; *Phil. Trans.* for 1805; John Farrar, "Elem. of Elect.," 1826, p. 381; "Cat. Sc. Papers Royal Soc.," Vol. I. p. 187.

A.D. 1801.—Gautherot (Nicholas), able French chemist (1753–1803), discovers that when a current has passed through two plates or wires of the same metal in dilute sulphuric acid, a secondary, reverse or polarization current is obtainable after disconnecting the battery. This was the first step in the storage of electricity and an account is given of it in the *Philosophical Magazine*, Vol. XXIV. pp. 185–186, which contains a report of the proceedings before the Galvani Society of Paris. Gautherot says that the results he obtained should become "the source or basis of several other experiments, and concur more than any other to the discovery of the theory of this new branch of physics."

In this same year Gautherot observed the power of adhesion of the two wires in contact with the upper and lower ends of the pile, a report upon which appears at p. 209, Vol. XXXIX of the *Annales de Chimie*, while a full account of his observations on the subject forms the substance of a separate work printed in London during the year 1828.

The French physicist, C. J. Lehot, makes allusion to the last-

named discovery in the following words, at p. 4 of his pamphlet entitled " Observations sur le Galvanisme et le Magnétisme " :

" It has long been known that the two wires which terminate a pile attract one another, and, after contact, adhere like two magnets. This attraction between the two wires, one of which receives, and the other loses, the galvanic fluid, differs essentially from electrical attraction, as Ritter observed, since it is not followed by a repulsion after contact, but continues as long as the chain is closed."

J. J. Fahie, who also quotes this passage, says :

" The discovery in question seems to have been made independently, and at about the same time by Gautherot (*Philosophical Magazine* or *Annals* for 1828, Vol. IV. p. 458), by P. S. Laplace, and by J. B. Biot (*Journal de Physique et de Chimie*, for 1801, Vol. LIII. p. 266). The latter made the further very acute observation that, if the wires are attached to plates of metal, and these plates approached by their edges, they will attract one another; while if approached by their faces no action whatever takes place. For other interesting experiments of this kind see ' Nicholson's Journal ' for 1804, Vol. VII. p. 304."

Previous to the aforesaid discoveries, on the 12th Brumaire, An. IX (Nov. 1800), Gautherot had published his refutation of Volta's contact theory, through the Paris " Société Philotechnique," and it is to be found recorded at p. 471, Vol. I of the " Mémoires des Sociétés Savantes et Littéraires de la République Française."

Later on he devoted so much attention to galvanic researches that Messrs. A. F. de Fourcroy and L. N. Vauquelin made a special report upon the five important memoirs containing the results of his many observations to the French Institute on the 21st Fructidor.

The first memoir gives the whole theory and practice of the various kinds of conductors, and describes an apparatus devised by Gautherot to ascertain the conducting powers of different natural, solid, liquid and even gaseous bodies (Izarn, " Manuel du Galvanisme," 1804, pp. 56–60). He enters into full details as to the effects of the voltaic pile in many experiments made upon himself, and draws consequences which apparently disprove the identity of the electric and the galvanic fluids.

The second memoir treats of the galvanic properties of charcoal, and shows that it is a less perfect conductor than are metallic substances.

In the third memoir he makes known his discovery that charcoal and zinc form a galvanic apparatus which will produce shocks, the decomposition of water, etc. He observes " that in the decomposition of water, charcoal decomposes that fluid in the same way with non-oxydable metals; or, in other words, that when two pieces of

charcoal are employed for this purpose, one of them disengages the hydrogen gas, and the other the oxygen . . . when the portions of charcoal touch each other in the water, its decomposition is not stopped on that account, as happens when metallic substances are brought in contact under the same circumstances. Indeed, if to bring more immediately together, one of the pieces of charcoal be cut in a furcated shape, this does not become an obstacle to the decomposition of the water."

The fourth memoir treats further of different kinds of conductors, and of various methods of constructing galvanic columns.

In the fifth and last memoir, Gautherot relates his important discovery that an effective galvanic apparatus can be made without metals. He constructed one of forty layers of charcoal and plumbago, which communicated a strong and pungent taste, accompanied by the galvanic flash of light, and which finally produced the decomposition of water, the charcoal side disengaging the hydrogen gas (Izarn, "Manuel du Galvanisme," 1804, p. 177).

During the month of March 1803, he read before the "Institut National" a memoir entitled "Recherches," etc. (researches upon the causes which develop electricity in the galvanic apparatus). This appeared in the *Journal de Physique*, Vol. LVI. p. 429.

REFERENCES.—"Biographie Générale," Vol. XIX. p. 694; Larousse, "Dict. Univ.," Vol. VIII. p. 1089; Izarn, Giuseppe (Joseph) "Manuel du Galvanisme," Paris, An. XII. 1804, s. 6, pp. 95, 250–254: *Mém. des Soc. Savantes*, etc., Vol. I. pp. 164, 168; P. Sue, aîné, "Hist. du Galvanisme," Paris, An. X, 1802, Vol. II. pp. 191, 196–203, 213, 214, 316; Alglave et Boulard, *Lumière Electrique*, Paris, 1882, p. 219; *Poggendorff*, Vol. I. p. 857; "Extrait d'une lettre de Brugnatelli," etc., Bruxelles, 1802 (Van Mons, *Journal de Chimie*, Vol. II. p. 216).

A.D. 1801.—Robertson (Etienne Gaspard), a very capable French experimentalist and one of the founders of the Paris Galvani Society, who has already been alluded to in the article relating to Sir Humphry Davy, writes a memoir, "Expériences nouvelles sur le fluide galvanique," which was read before the Institute on the 11th Fructidor, An. VIII, and which appeared in the *Annales de Chimie* (Vol. XXXVII. p. 132), as well as in the "Mémoires Récréatifs, Scientifiques," etc., published in Paris during 1840, three years after Robertson's death.

Robertson states that as he was delivering a lecture on the 9th Vendémaire, An. IX, during which he alluded to differences which he found to exist between the galvanic and electric fluids, he was interrupted by Prof. Brugnatelli, who stated that Volta, who was then present, desired an opportunity to correct the wrong impressions the lecturer laboured under. Volta called upon him early the day following and brought a live frog as well as apparatus, with which

they experimented quite extensively, and the results of which brought Robertson completely over to the views of the Italian scientist. Volta frequently repeated his visits, which led to the development of a lasting friendship between the two. They visited together all the prominent scientific bodies, such as l'Ecole de Médecine, l'Ecole Polytechnique, etc., but found to their great astonishment that Robertson was the only one in Paris who had as yet given the new discovery any serious attention. At pp. 250–253, Vol. I of his " Mémoires," etc., will be found a full account of the above as well as of the very indifferent reception first given them by the celebrated Prof. Charles.

Robertson adds (p. 256 of last-named work) that he was asked by Volta to witness the latter's notable experiments made before the members of the National Institute of France, Nov. 16, 18, 20, 1800, and already alluded to herein at A.D. 1775. The sessions of that body were being held at the time in the Palais du Louvre, and the excitement caused by the meetings was so great that all the approaches were guarded by soldiery. After Prof. Volta had explained his theory and alluded to the identity of electricity and galvanism, he announced that Robertson had first illustrated the fact, and he asked him to repeat his original experiment, which the latter did after the necessary hydrogen gas had been procured from the neighbouring cabinet of Prof. Charles.

Robertson is also the author of several other interesting memoirs on the electrophorus, the improved " couronne de tasses " and " acide galvanique " which can be found in Vol. XXXVII of the *Journal de Physique* and in the *Journal de Paris* for the year 1800 (" Recueil des Actes de la Soc. de Lyon," Tome II. p. 370).

A.D. 1801.—Gerboin (A. C.), Professor at the Medical School of Strasbourg, is the first to report upon the peculiar agitation of mercury when the voltaic current passes through it.

He states, in his " Recherches expérimentales sur un nouveau mode de l'action électrique " (Strasbourg, 1808), that his many researches were instigated by the observation he had made during the winter of 1798, while in company with some friends watching a child play with a hollow wooden ball. The Italian physicist, Abbate Fortis (1740–1803), who wrote several works on natural philosophy, but who is best known by his " Viaggio di Dalmazia," had already announced that a pyritical cube suspended by a thread held between the thumb and index would immediately, without any movement of the fingers, assume a circular motion upon being approached by another body. The " Morgenblatt " of Tübingen and the French " Archives Littéraires " render in 1807 a very

complete account of Ritter's researches upon the Fortis pendulum, and N. Meissas states, at pp. 181–187 of his "Nouveaux Eléments de Physique," Paris, 1838, that he repeated the experiment of Ritter and of his friend Gerboin and observed many very curious results. These he embodied in a communication during the month of April 1829 to Ampère, who looked into Meissas' work in company with M. Becquerel, also a member of the French Institute.

In his experiments, Gerboin employed a tube bent in U form, filled half full of mercury, which later was covered with a stratum of water, and he placed therein the wires connecting with a pile. The surface of the mercury beneath the negative pole was slightly oxidized, but the surface under the positive point moved so violently as to cause small bodies placed within to be thrown outward upon the surface of the tube. These bodies moved in a contrary direction, *i. e.* from the circumference toward the interior, if the positive pole was made to touch the liquid metal.

References.—Observations of M. Erman, of the Berlin Academy of Sciences, upon M. Gerboin's experiments related in the *Annales de Chimie*, Tome LXXVII. p. 32. Also, *Annales de Chimie*, Tome XLI. pp. 196, 197, *Mém. des Soc. Sav. et Lit.*, Vol. II. p. 199; Dr. Gore, "El. Metal," 1877, p. 3; De la Rive, "Treatise on Electricity," 1856, Vol. II. p. 433; Gmelin's "Chemistry," Vol. I. p. 487.

A.D. 1801.—Trommsdorff (Johann Bartholomäus), German chemist and pharmacist, who became Professor of Physics and Chemistry in the University of Erfurt, discovers that by employing large plates in galvanic batteries he can produce the combustion of fine wires and of thin leaves of metal.

After having obtained very strong shocks and large sparks, and effected the decomposition of water, etc., with his first pile consisting of 180 discs of copper, zinc and wet cardboard, he experimented with very thin leaves of the following metals, and found them to burn as follows: Gold, with a bright white light; silver, with a blue light; yellow copper, with a reddish blue light; red copper, with an emerald blue flame; zinc, with a bluish white flame; tin, with a reddish white light, etc. When oxidizing the noble or perfect metals, gold, silver, platinum, in hollow glass spheres, he found them to melt so thoroughly as to completely line the sides of the latter.

Trommsdorff afterward constructed a much larger pile of nearly 600 discs, not doubting that with a larger apparatus he could consume very thick plates. It was while carrying on subsequent experiments that MM. Fourcroy, Vauquelin and Thénard ascertained the fact that metals were more effectively deflagrated by piles with large plates than by piles having a great many plates of smaller surfaces.

In a letter dated Erfurt, March 16, 1801, Trommsdorff alludes to the galvanic decomposition of water spoken of at p. 98 of the "Archives du Nord pour la Physique et la Médecine," published at Copenhagen, and expresses doubts as to the correctness of the conclusions therein pointed out by Pfaff and Ritter.

REFERENCES.—"Encycl. Metrop." (Galvanism), Vol. IV. p. 221; "Roy. Soc. Sci. Papers," Vol. VI. pp. 45–52; *Poggendorff*, Vol. II. pp. 1136, 1137; C. H. Wilkinson, "Elem. of Galv.," London, 1804, Vol. II. pp. 134–136; J. S. Ersch, "Handbuch," etc., p. 119; L. F. F. Crell, "Chemische Annalen" for 1801; 4e Cah., p. 337; J. B. Van Mons, *Journal de Chimie*, Vol. I. p. 41; Larousse, "Dict. Univ., Vol. XV. p. 535. His pile is described at pp. 253–254, Vol. II of "Hist. du Galvanisme," P. Sue, aîné, Paris, An. X, 1802, with references to Von Crell's "Chemische Annalen," 1801, 4th Book, p. 237, and Van Mons' "Journal de Chimie," Vol. I. p. 41.

A.D. 1801.—Libes (Antoine), Professor of Natural Philosophy at the Collège de Beziers and at the Paris Ecole Normale and Lycée Charlemagne, publishes in three volumes, at Paris, his "Traité élémentaire de Physique," which had been preceded by his "Théorie de l'électricité," etc., and was followed by a valuable "Dictionnaire de Physique" in 1806 (C. F. V. Delaunay, "Manuel," etc., Paris, 1809).

In his "Traité," Prof. Libes dispels the previous generally accepted belief as to the production of electricity by pressure. Experiments made by Æpinus and by Haüy had shown that such minerals as developed positive electricity by friction likewise exhibited the same electricity by pressure, and that those furnishing resinous or negative electricity by pressure developed the same electricity by friction.

It is known that varnished silk (*taffetas gommé*) acquires resinous electricity by ordinary friction, but Libes found the means of causing it to develop vitreous or positive electricity. This is shown when a metallic disc insulated by a glass handle is *pressed* upon the silk; the latter will acquire positive electricity while the disc will develop resinous or negative electricity. If, on the contrary, the disc is *rubbed* or *rolled* upon the silk so as to produce friction, the silk acquires resinous electricity and the disc vitreous or positive electricity. If a glass plate is substituted for the disc, the silk again acquires vitreous electricity and the glass resinous electricity, that is to say, they both develop contrary electricities to that furnished through ordinary rubbing.

REFERENCES.—Larousse, "Dict. Univ.," Vol. X. p. 475; *Poggendorff*, Vol. I. pp. 1449, 1450; Volpicelli, "Sul cognito fenomeno. . . ." Roma, 1859; Haüy, "Traité Élémentaire de Physique," Paris, 1806, Vol. I. pp. 371, 372; A. C. Becquerel, "Expériences . . . par la pression," Paris, 1823; "Catal. of Sci. Papers of Roy. Soc.," Vol. IV. p. 5;

Thos. Thomson, "An Outline of the Sciences of Heat and Electricity," London and Edinburgh, 1830, p. 482; Dove, p. 229; "Encycl. Brit.," Vol. VIII, 1855, p. 563; *Annales de Chimie et de Physique*, Vol. XXII. p. 5; *Phil. Mag.*, Vol. LXII. pp. 204, 263.

A.D. 1801.—Fourcroy (Antoine François de), an eminent French chemist, physician and author, who succeeded Macquer in the professorship at the Jardin du Roi, for which Lavoisier was likewise a candidate, publishes (Vol. XXXIX. p. 103, of the *Annales de Chimie*) the result of galvanic experiments which he made in conjunction with Louis Nicholas Vauquelin (1763–1829), and also with Baron Louis Jacques Thénard (1777–1857), who, in turn, became the successor of Fourcroy as Professor of Chemistry at the Ecole Polytechnique. They thought that by using many discs they could increase the force of the current and also decompose water more rapidly, but found this was not the case, and that with an enlarged pile the combustion of metallic wires was more rapid and brilliant, thus proving that the degree of combustion is relative to the surface of the plates ("Encyclopædia Britannica," 1855, Vol. XXI. p. 626).

The grand experiment made conjointly by Fourcroy, Vauquelin and Seguin on the composition of water from its constituent gases was commenced May 13, 1790, and continued by them without intermission until its completion, nine days later. "The gases were fixed in a close vessel by means of electricity, and produced a nearly equal weight of water" (*Trans. Amer. Phil. Soc.*, N. S., Vol. VI. p. 339, giving description of apparatus for the decomposition and recomposition of water).

Fourcroy was also one of the savants appointed in 1798 by the Academy of Sciences of Paris to examine and report upon the experiments of Galvani. The committee was composed of Guyton de Morveau, Coulomb, Vauquelin, Sabathier, Pelletan, Charles, Fourcroy and Hallé, the last named being charged with the verification of all the then recent discoveries, which were repeated with the assistance of Humboldt, who went to Paris especially for the purpose. The official report fully endorsed the praiseworthy line of researches prosecuted by both Galvani and Humboldt, and the entire series of experiments was at once repeated by many leading physicists throughout Germany.

On June 19, 1803, one of Antoine Fourcroy's most interesting memoirs, treating of meteoric stones, was read by C. Fourcroy before the French Institute.

References.—*Phil. Mag.*, Vol. XVI. p. 299; Noad's "Lectures," pp. 183, 184; Ure, "Dict. of Chem."; also the interesting biography embracing a list of his very numerous works and treatises, at pp. 846–849, Vol. IX of 1855 "Encyclopædia Britannica." See likewise,

"Royal Society Catalogue of Scientific Papers," Vol. II. pp. 677–682; Thomas Thomson, "History of Royal Society," p. 454; Wilkinson's "Elements of Galvanism . . ." 1804, Vol. II. pp. 113, 145, 151, 152, 208, 359; Fahie's "History of Electric Telegraphy," p. 194; Izarn, "Manuel du Galv.," 1804, s. 4, p. 167; "Journal des Savants" for Jan. 1860; P. Sue, aîné, "Hist. du Galvanisme," Paris, 1802, Vol. II. pp. 159–160, 241, 264. For Louis N. Vauquelin, consult "Cat. Sc. Papers of Roy. Soc.," Vol. VI. pp. 114–128, 761; also "Mém. des Soc. Savantes et Litt.," Vol. I. p. 204.

A.D. 1801.—Lehot (C. J.), French physicist, sends a curious and lengthy memoir, regarding the circulation of a very subtile fluid in the galvanic chain, to the Institut National, before which body it is read on the 26 Frimaire, An. IX.

To the analyzation of the above-named memoir, Wilkinson devotes more than half the tenth chapter of his "Elements of Galvanism," calling attention to a very singular result from numerous experiments which is worthy of special mention. It is the possibility of actually distinguishing one metal from another without seeing or feeling either of them, and he says that by his arrangement of the chain, M. Lehot was able to recognize a portion of zinc from a piece of silver, at the extremity of metallic threads several yards in length.

Lehot's contributions to the science of animal electricity are too numerous to be given here. Noad summarizes them in the translation from pp. 17, 18 of C. Matteucci's "Traité des phénomènes . . ." Paris, 1844.

He ascertained that in a recently killed animal contractions are excited by the electric current in whatever direction it may be applied, but, when the vitality of the animal has become diminished, if the current is sent in the direction of the ramifications of the nerves, contractions are produced only at the *commencement* of the current; the reverse takes place when the current is directed contrary to the ramifications of the nerves; *i. e.* in this case the contractions only take place when the current ceases. After studying the sensation excited by the current on the organs of taste, Lehot concluded that the current which traverses a nerve in the direction of its ramifications excites a sensation when it ceases to pass, though this influence is only exerted at the *commencement* of its passage when the nerve is traversed in a direction contrary to its ramifications. The later experiments of Carlo Francesco Bellingeri and Stefano Giovanni Marianini entirely confirm those of Lehot.

References.—*Annales de Chimie*, Vol. XXXVIII. p. 42; *Journal de Physique*, An. IX, Pluviose, LII. 135; Gilbert, *Annalen*, IX. 188; P. Sue, aîné, "Hist. du Galvanisme," Vol. II. pp. 123, 124, 129, 132, 141, 142; "Encyclopedia Metropolitana," Vol. IV ("Electro-Magnetism," p. 8).

A.D. 1801.—Wollaston (William Hyde), celebrated English chemist and natural philosopher, an associate of Sir Humphry Davy, who had taken the degree of M.D., and joined the Royal Society in 1793, but soon abandoned the practice of medicine to devote himself exclusively to scientific researches, is the first to demonstrate the identity of galvanism and frictional electricity, through a paper read before the above-named society in June 1801.

The latter communication shows that he succeeded in decomposing water as rapidly by means of mere sparks from frictional electricity as through the agency of the voltaic pile, and in a more tranquil and progressive manner than can be assured through shocks from large and powerful apparatus. He concluded that the decomposition must depend upon duly proportioning the strength of the charge to the quantity of water, and that the quantity exposed to its action at the surface of communication depends on the extent of that surface. He observes :

"Having procured a small wire of fine gold, and given to it as fine a point as I could, I inserted it into a capillary glass tube, and after having heated the tube so as to make it adhere to the point and cover it at every part, I gradually ground it down till, with a pocket lens, I could discern that the point of gold was disclosed. I coated several wires in this manner, and found that when sparks from a conductor were made to pass through water by means of a point so guarded, a spark passing to the distance of $\frac{1}{8}$ of an inch would decompose water, when the point did not exceed $\frac{1}{700}$ of an inch in diameter. With another point, which I estimated at $\frac{1}{1500}$, a succession of sparks $\frac{1}{20}$ of an inch in length afforded a current of small bubbles of air. With a still finer filament of gold, the mere current of electricity, without any perceptible sparks, evolved gas from water."

In his Bakerian lecture of Nov. 20, 1806, Sir Humphry Davy relates experiments made after the manner contrived by Wollaston, showing that the principle of action is the same in common as in voltaic electricity. Dr. Robert Hare, in a paper read before the Academy of Natural Sciences, "On the Objections to the Theories Severally of Franklin, Dufay and Ampère," etc., says that, instead of proving the identity of galvanism with frictional electricity, the above-named experiments show that in one characteristic at least there is a discordancy, but that at the same time they possibly "indicate that ethereal may give rise to ethereo-ponderable undulations." Noad remarks that in these ingenious experiments true electro-chemical decomposition was not effected; that is, "the law which regulates the transference and the final place of the evolved bodies had no influence." The water was decomposed

at both poles independently of each other, and the oxygen and hydrogen gases evolved at the wires are the elements of the water before existing in those places. Faraday observes :

"That the poles, or rather points, have no mutual decomposing dependence, may be shown by substituting a wire or the finger for one of them, a change which does not at all interfere with the other, though it stops all action at the charged pole. This fact may be observed by turning the machine for some time ; for though bubbles will rise from the point left unaltered in quantity sufficient to cover entirely the wire used for the other communication, if they could be applied to it, yet not a single bubble will appear on that wire."

Wollaston communicated a paper to the Royal Society (*Phil. Trans.*, Vol. XCI. p. 427) showing that the oxidation of the metal is the primary cause of the electrical phenomena obtained in the voltaic pile. The oxidating power is finely shown by his eighth experiment, which he thus describes :

"Having coloured a card with a strong infusion of litmus, I passed a current of electric sparks along it, by means of two fine gold points, touching it at the distance of an inch from each other. The effect, as in other cases, depending on the smallness of the quantity of water, was most discernible when the card was nearly dry. In this state a very few turns of the machine were sufficient to occasion a redness at the positive wire, very manifest to the naked eye. The negative wire, being afterward placed on the same spot, soon restored it to its original blue colour."

He verified in 1802 the laws of double refraction in Iceland spar announced by Huyghens, and wrote a treatise thereon which was read before the Royal Society on the 24th of June, and which contains additional evidence deduced from Dr. Wollaston's superior mode of investigation.

He is said to have been the first to propose forming the spectrum by using a very narrow pencil of daylight instead of sunlight, and to have first made an accurate examination of the electric light. In his communication to the Philosophical Transactions for 1802 he says :

"When the object viewed is a *blue* line of electric light, I have found the spectrum to be separated into several images ; but the phenomena are somewhat different from the preceding (viz. the spectrum of the blue portion of the flame of a candle). It is, however, needless to describe minutely appearances which vary according to the brilliancy of the light, and which I cannot undertake to explain."

During the year 1815, Wollaston made a great improvement in

the construction of voltaic batteries. Having observed that the power of a battery is much increased with a corresponding economy in zinc plates, when both zinc surfaces are opposed to a surface of copper, he devised what he called an *elementary galvanic battery*. Each couple of the latter is made up only of a plate of copper doubled up around a zinc plate from which it is kept apart by strips of cork or wood, and the connecting strips of metal are attached to a wooden rod which is lowered or elevated when the battery is in or out of action. He found that a properly mounted plate of zinc, one inch square, was more than sufficient to ignite a wire of platina $\frac{1}{3000}$ of an inch in diameter, even when the acid is very diluted (fifty parts of water to one of sulphuric acid).

He was a very careful workman, and in order to adapt his apparatus to the popular uses, he generally endeavoured to construct them upon the most reduced scale (*dans des proportions très exigues*). He produced platinum wire so extremely fine as to be almost imperceptible to the naked eye. It was estimated that 30,000 pieces of this wire, placed side by side in contact, would not cover more than an inch; that it would take 150 pieces of this wire bound together to form a thread as thick as a filament of raw silk, and that a mile of this wire would not weigh more than a grain. It may be well to add here that the wire made with John Wennstrom's sapphire plates, for delicate electrical apparatus, is so fine that thirty-six miles of it, properly insulated for Government use in torpedo experiments, measures only about five inches in length by three in diameter when wound upon a spool. The fibre used as carbon filaments in the incandescent lamps is scraped to an even thinness by being drawn through sapphire plates from $\frac{30}{1000}$ to $\frac{4}{1000}$ of an inch in diameter.

The smallest battery that Wollaston formed of the above-described construction consisted of a thimble without its top, flattened until its opposite sides were about two-tenths of an inch asunder. The bottom part was then nearly one inch wide and the top about three-tenths, and as its length did not exceed nine-tenths of an inch, the plate of zinc to be inserted was less than three-fourths of an inch square (*Annals of Philosophy*, Vol. VI. p. 210).

We are also indebted to Dr. Wollaston for the first idea of the possibility of producing electromagnetic rotations. Prof. Schweigger opposed the action of revolving magnetism upon the ground that if it were true, a magnet might be made to revolve around the uniting wire, but Faraday found experimentally not only that a magnet could be made to revolve round the uniting wire, but that a movable uniting wire might be made to revolve around a magnet. (See Faraday's "Experimental Researches," Vol. II.

pp. 159–162 for "Historical Statement Respecting Electromagnetic Rotation.")

Wollaston was made secretary of the Royal Society in 1806, became its president in 1820 after the death of Sir Joseph Banks, and contributed in all thirty-eight memoirs to the *Philosophical Transactions* of that Institution.

His death occurred Dec. 22, 1828, and during the following February Dr. Fitton, President of the Geological Society, concluded his annual address with the following encomium:

"It would be difficult to name a man who so well combined the qualities of an English gentleman and a philosopher, or whose life better deserves the eulogium given by the first of our orators to one of our most distinguished public characters; for it was marked by a constant wish and endeavour to be useful to mankind."

References.—*Phil. Mag. or Annals*, Vol. V. p. 444. See also "The Roll Call of the Royal College of Physicians of London," by William Munk, M.D., Vol. II; *Edin. Phil. Jour.*, Vol. X. p. 183; Gmelin's "Chemistry," Vol. I. p. 424; De la Rive, "Treatise on Electricity," pp. 444, 445; *Phil. Mag.*, Vol. XXXIII. p. 488; LXIII. p. 15; James Napier, "Manual of Electro-Metallurgy," 4th Am. ed., pp. 492, 518; Desbordeaux, in *Comptes Rendus*, Vol. XIX. p. 273; *Le Moniteur*, No. 40 for 1806; Sue, aîné, "Galvanisme," Vol. II. pp. 193–195, 199, 202; Joseph Izarn, "Manuel du Galvanisme," p. 137; *Poggendorff*, Vol. II. p. 1362; "Encycl. Metrop.," Vol. IV (Galvanism), pp. 180, 181, 216, 222; *Nicholson's Journal*, Vol. V. p. 333; Thos. Young, "Lectures," London, 1807, Vol. II. p. 679; W. Sturgeon, "Scientific Researches," Bury, 1850, p. 29; *Quarterly Journal of Science* for January 1821; *British Quarterly Review* for August 1846; "Biog. Générale," Tome XLVI. p. 822; Highton's "Electric Telegraph," p. 14; Larousse, "Dict. Universel," Tome XV. p. 1370; "Cat. Sc. Papers . . . Roy. Soc.," Vol. I. p. 61; Vol. II. pp. 136, 199; "Bibl. Britan.," 1801, Vol. XVIII. p. 274; 1810, Vol. XLIII. p. 347 (*Phil. Mag.*, June 1809); Vol. I., N.S., 1816, p. 119.

A.D. 1802.—Walker (Adam), English writer and inventor of several very ingenious mathematical instruments, publishes in London his enlarged edition of "A System of Familiar Philosophy," two volumes, 8vo, in which he devotes ss. 5–9 of Lecture II. vol. i. to magnetism, and all of Lectures VII and VIII of the second volume to electricity.

We are informed, through his preface, that "the identity of fire, light, heat, caloric, phlogiston and electricity, or rather their being but modifications of one and the same principle, as well as their being the grand agents in the order of nature . . . are the leading problems of the work." In another part he tells us:

"If electricity, light and fire be but modifications of one and the same principle . . . and they have their origin or foundation in the sun, it is natural to suppose, in issuing from that luminary, they proceed from him first in their purest state, or in the character

of electricity; that joining the particles of our atmosphere, electricity becomes *light*, and uniting with the grosser earth, *fire* . . . that this *fire* shall be culinary when called forth from the earth by ordinary *combustion*, and electric when called forth by *friction*. Thus have I exhibited this wonderful agent in most of the lights in which it has yet been seen; and flatter myself the reader's deductions from these appearances will be similar to my own, viz. that electricity emanates in a perfect state from the sun and fixed stars; that its particles repel each other and fill all space; that they have an affinity to the earth and planets, but an affinity that cannot easily be gratified, because the surrounding atmospheres are in part non-conductors, being already saturated, and, of course, repellent of the electric fluid" (Lecture VIII. p. 72).

In the section devoted to "Miscellaneous Observations," he remarks that the magnetic power may almost be said to be created by friction, rather than communicated by it; for a magnet acquires strength by giving magnetism to iron; so that, if all the magnets in the world were lost, magnetism might be revived by rubbing the end of one steel bar against the side of another.

Section V, treating of "Magnetic Attraction," concludes as follows: "How far these observations and experiments go to establish the doctrine of a magnetic effluvium flowing through the earth, or from one end of a magnet to the other, must be left to the reader's judgment and opinion. We are apt to laugh at the *subtil matter* of Descartes and the *aether* of Euler, as occult qualities, which modern philosophy will not admit into its creed, but this effluvium is a *subtil* matter, an *aether*, equally as inexplicable and as equally out of the reach of our five senses to scrutinize; however, if we may venture to guess at causes by effects, and to compare analogies with what we can see, feel, etc., I think we have infinite data in favour of an electro-magnetic fluid, superior to any proof that can be brought of æther being the cause of gravity, light, vision, etc."

John Read's letter to the author concerning the *electrophorus* appears at pp. 47–49 of the second volume (Poggendorff, Vol. II. pp. 1248–1249).

A.D. 1802.—Alexandre (Jean), who is said to have been the natural son of Jean Jacques Rousseau, and to have studied for the medical profession, operates his secret telegraph (*télégraphe intime*) at Poitiers, and afterwards addresses M. Chaptal, Ministre de l'Intérieur, asking for financial aid in order that he may be enabled to go to Paris and submit his invention to the French Government. This request being refused on account of Alexandre's

unwillingness to divulge his secret, he next obtained an audience of M. Cochon, Prefect of Vienne, before whom he demonstrated his invention so successfully that the latter was induced to make a report of it to M. Chaptal, advising him to invite Alexandre to Paris at the expense of the State. A second refusal, however, followed, and Alexandre went to Tours, where he there also failed to obtain the desired assistance, after giving successful exhibitions of his telegraph before the Prefect of Indre-et-Loire, General Rommereul, as well as before the Mayor and the city officials.

The substance of Prefect Cochon's communication is to be found translated at pp. 111–113 of Fahie's "History of Electric Telegraphy," which latter also contains a full translation of the report addressed, 10 Fructidor, An. X by the celebrated French astronomer, J. B. J. Delambre, to the First Consul, suggesting for the inventor's representative, M. Beauvais, an interview which Bonaparte, however, refused to grant.

Alexandre died, 1832–1833, without having revealed his secret to any one but M. Beauvais. It is stated by Fahie that in the English *Chronicle* of June 19–22, 1802, appears a brief account of the above-named exhibition given at Tours, concluding as follows: "The art or mechanism by which this is effected is unknown, but the inventor says that he can extend it to the distance of four or five leagues, even though a river should be interposed." A copy of the above-named newspaper, doubtless unique, was in Latimer Clark's library.

References.—"Annales Télégraphiques," March–April, 1859, pp. 188–199, for M. Edouard Gerspach's Memoir; "Sci. Am. Suppl.," No. 384, for a translation of M. Auguste Guéroult's article in "La Lumière Electrique"; M. Cézanne, "Le Cable Transatlantique," Paris, 1867, p. 32; M. Bério, "Ephemerides of the Lecture Society," Genoa, 1872, p. 645.

A.D. 1802.—Sue (Pierre, aîné), a very able French physician, publishes, at Paris, "Histoire du Galvanisme et analyse des différents ouvrages publiés sur cette découverte . . ." which is considered by scientists one of the most important works on the subject.

References.—"Biographie Générale," Vol. XLIV. pp. 618–619; Larousse, "Dictionnaire Universel," Vol. XIV. p. 1200; Wilkinson, "Elem. of Galv.," 1804, Vol. I. p. 182.

A.D. 1802.—Brugnatelli (Luigi Valentino), who, after being a pupil, became the close friend and subsequently the colleague of Volta at the Pavia University, is the first to obtain, by means of the voltaic pile, a decidedly practical result in electro-plating. He gilded two large silver medals on bringing them in communication, by means of the steel wire, with the negative pole of a voltaic pile,

and by keeping them one after the other immersed in ammoniurets of gold newly prepared and well saturated (*Phil. Mag.* for 1805).

He also electro-deposited bright metallic silver upon platinum, and observed that when the current entered the liquid by means of a pole of copper or zinc, those metals were dissolved and then deposited upon the negative pole. Spon tells us (" Dictionary of Engineering," London, 1874, Vol. II. p. 1378) that the solutions employed by Brugnatelli were alkaline; they consisted of ammoniurets of gold, silver or platina, that is, the product obtained by treating the chlorides of gold and platina or the azotate of silver, by ammonia. There is much obscurity in the descriptions of Brugnatelli, but according to the *Journal de Physique et Chimie* of Van Mons, the most expeditious method of reducing, by means of the battery, dissolved metallic oxides, is to make use of their ammoniurets by placing the ends of two conducting wires of platina into ammoniuret of mercury. The wire of the negative pole speedily becomes covered with small particles of this metal. MM. Barral, Chevalier and Henri tried to reproduce Brugnatelli's operation by following his descriptions, but with very imperfect results, the nature of the dissolvent employed by the learned Italian not being known.

At p. 136, Vol. XVIII of his *Annali di Chimica*, etc., Brugnatelli publishes a memoir entitled " Chemical Observations on the Electric Acid." He says :

" Naturalists have hitherto merely abandoned one erroneous hypothesis for another, in considering the nature of the electric fluid. Some have regarded it as identical with heat; while others have been led to consider it as a modified caloric. The disciples of Stahl ascribed it to the nature of their *phlogistic* or, at least, supposed it to be a fluid abundantly provided with that principle. Henley conjectured it to be phlogistic, when in a state of repose, and fire, when in a state of activity. Among the moderns, several have been found who have declared it to be an acid; but their opinion has been combated by Gardini, who, by means of several ingenious observations, has endeavoured to demonstrate that it is composed of caloric and hydrogen."

In the earlier experiments on the decomposition of even chemically pure water by the voltaic column, the presence of an acid was always apparent at the pole evolving oxygen, while alkaline matter appeared at the other (*Nicholson's Journal*, quarto, Vol. IV. p. 183).

Mr. William Cruikshanks supposed the former to be the nitrous acid resulting from a combination of the oxygen at the positive pole with the azote of the air held in solution by the water, while

the alkali, he said, proceeded from the combination of the same principle with the hydrogen evolved at the negative pole (*Nicholson's Journal*, quarto, Vol. IV. p. 261). Mr. C. B. Desormes afterward endeavoured to show that the products were ammonia and muriatic acids (*Annales de Chimie*, Vol. XXXVII. p. 233). Brugnatelli's experiments with the *couronne de tasses*, however, led him to consider it to be an acid *sui generis* produced by the combination of one of the constituents of water with positive electricity. He classed it as *oxi-electric*, and of all the metals, gold and platina alone appeared to him not to be sensibly affected by this electric acid.

REFERENCES.—For Brugnatelli's record of other experiments and observations and for his Memoirs upon different piles, upon animal electricity, upon the identity of the electric and galvanic fluids, etc. etc., see his " Principes," etc., 1803, and " Grundsätze des Elektricität," etc., 1812, his *Annali di Chimica*, Vols. VII. p. 239; XIX. pp. 77, 153, 274, 277, 280–281; XXI. pp. 3, 143, etc., 239; XXII. pp. 1, etc., 77–92, 257, 301; the *Giornale di Chimica, Fis. e Storia Nat.* of L. and G. Brugnatelli, G. Brunacci and P. Configliachi, Vol. I. pp. 147–163, 337–353; IX. p. 145; XI. p. 130, and the " Commentarii Medici," edited by L. Brugnatelli and L. V. Brera; also Brugnatelli's *Giornale Fisico-Medico*, etc., and its continuation, *Avanzamenti della Medicina e Fisica*, the first named containing (Vol. I. p. 280), a repetition of Galvani's experiments, made by Volta, Rezia and Brugnatelli; G. Bianconi, " Intorno . . ." and " Cenni intorno . . . Galvanoplastica " (*Nuovi Annali della Scienze Naturali*); the " Biblioteca Italiana," of which his son Gaspare Brugnatelli was an editor, in conjunction with Breislak, Configliachi, Carlini, Cotena, Acerbi, Brunacci, Fantonelli, Fumagelli, Ferrario, Giordiani, Gironi and Monti; G. A. Giobert, " Gior. Fis. Med.," 1188; Du Pré, " Ann. di Chimica," IX. 156; P. Mascagni, " Lettera . . ." for Brugnatelli's notes; A. Cossa, " Notizie . . . elettro-chimica," 1858; J. Napier, " Man. of El. Met.," 4th ed., pp. 491, 492; J. B. Van Mons' *Journal de Chimie*, Vols. I. pp. 1, 24, 101, 216, 325; II. pp. 106, 216; IV. p. 143; X. p. 114; XVI. p. 132; also Vol. LXXVI; *Giornale di Fis. Chim.*, Vol. I. pp. 4–32, 28, 139–147, 164–166, 338; " Effemeridi Chim. Mediche di Milano," 1807, Sem. I. p. 57; A. F. Gehlen's *Journal für die Chemie*, Vol. I. pp. 54–88; VI. pp. 116–124; VIII. pp. 319–359; L. W. Gilbert, *Annalen der Physik*, Vols. VIII. pp. 284–299; XVI. pp. 89–94; XXIII. pp. 177–219; *Philosophical Magazine*, Vols. XXI. p. 187; XXV. pp. 57–66, 130–142; LIII. p. 321; Dr. Thos. Thomson's *Annals of Philosophy*, Vol. XII. p. 228; Alfred Smee's " Elements of Electro-Metallurgy," *History*, pp. xxv–xxvi; *Journal de Pharmacie*, Vol. III. pp. 425, 426; J. Nauche, *Journal du Galvanisme*, etc., Vol. II. pp. 55–60; P. Sue, aîné, " Histoire du Galvanisme," An. X, 1802, Vol. I. p. 305; II. pp. 263, 316, 320, 328; *Annales de Chimie*, Feb, 1818; for Brugnatelli, " Biblioth. Britan.," Vol. XXXI., 1806, pp. 43, 122, 223 (pile végétale).

A.D. 1802.—Jäger (Karl Christoph Friedrich van), a well-known physicist of Wurtemberg and professor at Stuttgart, confirms by mathematical analysis the theory of electrical distribution and equilibrium, as will be seen by his papers in Gilbert's *Annalen der Physik*, Vols. XII. pp. 123, 127; XIII. pp. 399–433; XXIII. pp. 59–84, and LII. pp. 81–108.

The views of Jäger were fully endorsed by Berzelius, who, like Scholz and Reinhold, endeavoured to extend them, and who says that we are indebted to the German physicist for actually the most complete elucidation of the theory of the voltaic pile.

In Vol. XLIX of Gilbert's *Annalen* for 1815, pp. 47–66, will be found Jäger's observations and experiments on Zamboni's column as well as the papers of Zamboni and Deluc on dry piles. Dr. Thomson says that since Dr. Jäger found that, when the temperature was raised to 104 degrees, or as high as 140 degrees, the pile begins again to act as well as ever, we must conclude from this that dry paper, while cold, is a non-conductor of electricity, but that it becomes again a conductor when heated up to 104 degrees or 140 degrees.

REFERENCES.—Poggendorff, Vol. I. pp. 1186, 1187; "Catalogue of Scientific Papers of the Royal Society," Vol. III. p. 525; Jäger on the tourmaline in Gilbert's *Annalen* for 1817, Vol. LV. pp. 369, 416, and Jäger, Bohnenberger and Zamboni in the *Annalen* for 1819, Vol. LXII. pp. 227–246; Figuier, "Expos. et Histoire," 1857, Vol. IV. p. 433; Davy, "Bakerian Lectures," 1840, pp. 44–56, on the "Agencies of Electricity."

A.D. 1802.—Gale (T.), an American physician, publishes at Troy "Electricity or Ethereal Fire . . . considered naturally, astronomically and medically, and comprehending both the theory and practice of medical electricity," etc. Among other things, he describes at pp. 27, 28, various experiments made with his galvanometer; explains at pp. 46–64 how the Newtonian principles are erroneous; and shows at p. 264 how to extract lightning from the clouds; while at pp. 272, etc., are given directions for using electricity both as a sure preventive and cure of diseases.

A.D. 1802.—Gibbes (George Smith), M.D., of Bath, reads before the Royal Society a paper on the Phenomena of Galvanism thus noticed by Dr. Young at pp. 672, 673, Vol. II. of his "Course of Lectures," London, 1707:

"Dr. Gibbes begins with reciting some experiments on the oxidation produced during the union of tinfoil with mercury, first in the air and then under water. He assumes a different opinion from that of Dr. Wollaston, respecting the origination of electricity in chemical changes, and maintains on the contrary that the electrical changes are to be considered as preceding and favouring the chemical. He imagines that the simple contact of various substances produces changes of electrical equilibrium, and that the action of acids is effectual in promoting these changes, by bringing their surfaces into contact. Dr. Gibbes observes upon Dr.

Wollaston's experiment of immersing zinc and silver in an acid solution, that if they are placed in two separate portions of the fluid, and the parts not immersed are brought into contact there is no emission of gas from the silver; but that it is copiously produced when the contact takes place in the same fluid. He proceeds to relate some experiments which seem to show a difference between galvanism and electricity, particularly that galvanism does not appear to be attracted by metallic points. He also states an experiment in which a piece of paper is placed on tinfoil, and rubbed with elastic gum, and although the tinfoil is not insulated, sparks are produced on raising the paper. Dr. Gibbes concludes with some arguments against the doctrine of the decomposition of water; and advances as a probable opinion, that oxygen and hydrogen gas are composed of water as a basis, united with two other elements, which, combined, form heat."

As remarked by Wilkinson (" Elements of Galvanism," London, 1804, Vol. II. pp. 385, 386), Dr. Gibbes' hypothesis as to the composition of water having been deduced from Richter's experiments, and these latter proving erroneous, the ingenious superstructure which the doctor has erected must necessarily fall to the ground.

A.D. 1802.—Romagnosi (Gian Domenico Gregorio Giuseppe), Italian jurist of Salsomaggiore, near Piacenza, who had devoted much time to scientific investigation, and was about taking the law professorship at the Parma University, communicates, Aug. 3, 1802, to the *Gazetta di Trento,* his important paper entitled " Articulo sul Galvanismo." Of the latter, a translation, made from the reprint at p. 8 of Gilb. Govi's " Romagnosi e l' Elettro-magnetismo," appears at pp. 259, 260 of Fahie's " History of Electric Telegraphy."

To Romagnosi has by many been given the credit of having discovered the directive influence of the galvanic current upon a magnetic needle. This claim has of late years been again made for him, notably by Dr. Donato Tommasi, of Paris (*Cosmos, les Mondes* of June 30, 1883), while Dr. J. Hamel endeavoured to prove (pp. 37–39 of " Historical Account . . . Galv. and Mag. Elec. . . ." reprinted by W. F. Cooke for the Society of Arts, London, 1859) that Oersted was aware of Romagnosi's experiments at the time he published the discovery of electro-magnetism. This is what Dr. Hamel says:

" I cannot forego stating my belief that Oersted knew of Romagnosi's discovery announced in 1802, which was eighteen years before the publication of his own observations. It was mentioned in the book of Giovanni Aldini (the nephew of Galvani)

. . . Oersted was in Paris 1802 and 1803, and it appears from the book of Aldini, that at the time he finished it Oersted was still in communication with him; for he says at the end (p. 376) he had not been able to add the information received from Oersted, Doctor of the University at Copenhagen, about the galvanic labours of scientific men in that country. . . . It deserves to be remembered, that from Aldini's book (" Essai théorique et expérimental sur le galvanisme," etc., Paris, 1804, qto. p. 191, or Vol. I. of the 8vo ed., pp. 339–340) it was known that the chemist, Giuseppe Mojon (Joseph Mojon, in the French), at Genoa, had before 1804 observed in unmagnetized needles exposed to the galvanic current 'a sort of polarity.' Joseph Izarn repeats this also in his 'Manuel du Galvanisme' (Paris, An xii., 1804, sec. iii. p. 120, or 1805, sec. ix.), which book was one of those that by order were to be placed in the library of every lycée of France."

Robert Sabine remarks (" The Electric Telegraph," 8vo, 1867, p. 22; " History of the Electric Telegraph," in Weale's Rudimentary Treatises, 1869, pp. 23, 24; " History and Progress of the Electric Telegraph," 3rd ed., 1872, p. 23):

" The discovery of the power of a galvanic current to deflect a magnetic needle, as well as to polarize an unmagnetized one, were known to, and described as early as 1804, by Prof. Izarn. . . . The paragraph which especially refers to this subject is headed 'Appareil pour reconnaitre l'action du galvanisme, sur la polarité d'une aiguille aimantée.' After explaining the way to prepare the apparatus, which consists simply in putting a freely suspended magnetic needle parallel and close to a straight metallic conductor through which a galvanic current is circulating, he described the effects in the following words: 'According to the observations of Romagnosi, a physicist of Trent, a magnetized needle which is submitted to a galvanic current undergoes (*éprouve*) a declination; and according to those of J. Mojon, a learned chemist of Genoa, unmagnetized needles acquire by this means a sort of magnetic polarity.' To Romagnosi, physicist of Trent, therefore, and not, as is generally believed, to Oersted, physicist at Copenhagen (who observed, in 1820, the phenomenon of the deflection of a magnet needle by a voltaic current), is due the credit of having made this important discovery."

On the other hand, Gilb. Govi, who gives in his afore-named work a good illustration of Romagnosi's experiment, explains that it resembles in no way the experiment of Oersted, there being no magnetic action of the column on the magnetic needle, which latter is in fact repelled by the mere electricity of the pile. Ronalds states that Romagnosi's experiment, much like that made by

Schweigger (A. F. Gehlen's *Journal für die Chimie und Physik*, 1808, pp. 206–208), was a modification if not a repetition of the one which Thomas Milner performed with static electricity (T. Milner's "Experiments and Observations in Electricity," London, 1783, p. 35), wherein a magnetic needle forms the electrometer since improved upon by J. C. A. Peltier.

To the ordinary mind, a conclusive proof that Romagnosi had no part in the discovery of electromagnetism would seem to be, as Fahie rightly observes, the fact that he himself never claimed any, although he lived until 1835, fifteen years after the announcement made by the Danish philosopher. Fahie calls attention, for some experiments in the same line, to J. B. Van Mons' *Journal de Chimie*, Bruxelles, January 1803, p. 52, and to Nicholson's *Journal of Nat. Phil.*, Vol. VII. p. 304, as well as to the 1746 and 1763 *Phil. Trans.* for investigations made by B. Robins and Ebenezer Kinnersley, and he likewise alludes to others recorded in the *Amer. Polytechnic Review* for 1831, and in the *Quarterly Journal of Science and the Arts* for 1826, to all of which, he says, as little real attention should be given as can properly be attached to the observations of Aldini and of Izarn previously referred to.

References.—"Notizia di G. D. Romagnosi, stesa da Cesare Cantù," Milan, 1835; "Nuova Scelta d' Opuscoli," Vol. I. p. 201; *Gazetta di Roveredo* for 1802, No. 65; "Atti della Reale Accad. delle Scienze di Torino," Vol. IV, April 7, 1869; J. C. Poggendorff, Vol. II. pp. 681, 682; S. I. Prime's "Life of Morse," 1875, p. 264; *Phil. Mag.*, Vol. LVIII. p. 43; *Journal Soc. of Arts*, April 23, 1858, p. 356, and July 29, 1859, pp. 605, 606; *Bibl. Ital.*, Vol. XCVIII. p. 60; Gilbert, *Annalen*, 1821, Vol. LXVIII. p. 208; Larousse, "Dict. Univ.," Vol. XIII. p. 1318; "Biographie Générale," Vol. XLII. pp. 574, 575, the last named remarking that the discovery alluded to in the works of Aldini and Izarn passed unnoticed till Oersted caused its value to be fully appreciated.

A.D. 1802.—Parrot (George Friedrich), Russian physician and professor at Dorpat, is, of all the European savants, the one who developed most extensively the chemical theory of the voltaic pile. The superior manner in which all his observations were carried on have led many to consider him justly entitled to the credit of being the founder of the theory (Figuier, "Exposition et Histoire," etc., Paris, 1857, Vol. IV. chapitre viii. pp. 426–429).

He commenced his experiments in 1801, and first recorded them in a memoir which was crowned the same year by the Batavi Scientific Society of Haarlem. His other papers on the same subject followed in rapid succession, mainly through L. W. Gilbert's *Annalen der Physik*, under such heads as: "Sketch of a New Theory of Galvanic Electricity, and Concerning the Decomposition of Water," etc. ("Combination of Induction and Chemical Action," Gilb., Vol. XII. p. 49, Seypfer, p. 200), "How to Measure Electricity,"

"Relative to the Electrometer," "The Effects of the Condenser," and "The Theory of Volta Concerning Galvanic Electricity," all of which appeared in Vol. LXI. of the *Annalen*. These papers were alluded to in his letter to the editors of the *Annales de Chimie et de Physique* (*An. Ch. et Phys.*, Vol. XLII. p. 45), and were afterward greatly amplified in his "Treatise on Natural Philosophy."

Parrot started with the determination to demolish completely the theories of Volta and to thoroughly instruct him anew (*instruire de toutes pièces le procès du physicien de Pavie*), and it must be admitted that the many important facts enounced by Parrot were such as would have ordinarily created a disturbing influence, but they became known after Volta's views had been thoroughly espoused by many German and French scientists and consequently attracted comparatively little attention.

At p. 466, Vol. II of Dr. Thomas Young's "Course of Lectures," London, 1807, reference is made to a paper in Gilbert's *Annalen der Physik* (X. p. 11, also XIII. p. 244), concerning Parrot's theory of evaporation, with mention of the fact that the same paper contains a proposal for inoculating the clouds with thunder and lightning, by projecting bombs to a sufficient height.

Parrot also devised a scheme for telegraphing, which is described in the *Mem. Acad. Petropol.*, ser. vi. Vol. I for 1838, and is alluded to in the Report on Telegraphs for the United States, made at request of the Hon. Levi Woodbury, Secretary of the Treasury, by the Committee on Science and the Arts of the Franklin Institute. The proposed telegraph, as worded in the Report, "consists of a single arm or *indicator*, which should be about nine feet long and one foot wide, with a cross-piece at one end, about three feet long and one wide; the whole being movable about an axis at its centre. . . . The movements may be communicated with ease and certainty, either by an endless chain passing over a wheel on the axis, and a wheel in the building; or by a cog-wheel on the axis, and an endless screw on a vertical bar. For night signals, three lamps are used, one swinging beyond the end of the arm, the other two beyond the ends of the cross-piece."

References.—Gilbert's *Annalen*, Vols. XXI for 1805, LV for 1817, LX for 1819; J. H. Voigt's *Magazin*, Vol. IV; Grindel's "Russ. Jahrb. f. Chem. u. Pharm.," XI, 1810; L. Turnbull, "Elec. Mag. Tel.," p. 19; "Naturwiss. Abhandl. aus Dorpat.," I, 1823; "Roy. Soc. Cat. of Sc. Papers," Vol. IV. pp. 765–767; *Annales de Chimie*, Vol. XLII, 1829, pp. 42–45, and Vol. XLVI, 1831, p. 361; "Mém. sixième série Sc. Mathém.," first part of Vols. III and V; "Pander's Beitr. z. Naturk, I."

A.D. 1802–1806.—Berzelius (Baron Jöns Jacob Freiherr von), M.D., one of the greatest of modern chemists, native of East

Gothland, Sweden, publishes his "De Electricitatis . . ." or "Physical Researches on the Effect of Galvanism upon Organized Bodies," which established his reputation as an experimental philosopher and procured for him the appointment of Assistant Professor of Medicine, Botany and Chemical Pharmacy at Stockholm. Of the very great number of scientific papers which he communicated to learned Societies, that entitled "An Essay on the Division of Salts through Galvanism" deserves especial mention, for in it, he lays down the electro-chemical theory, the honour of being the original propounder of which is by many claimed for Sir Humphry Davy.

In conjunction with Gottlieb Gahn, with W. Hisinger, of Elfstorps Bruk, and with the Swedish physician, Magnus Martin de Pontin, Berzelius made many very extensive observations and published numerous treatises, the most important of which are embraced in the papers named at foot (Sir Humphry Davy, "Bakerian Lectures," London, 1840, more particularly at pp. 13, 20, 109, 111, 122–123).

As has been before observed, the brilliant investigations of Berzelius and Hisinger, together with those of Nicholson and Carlisle, of Dr. William Henry and of Sir Humphry Davy, actually created a new epoch in the history of chemistry. Prof. Wm. B. Rogers better expressed the fact in his address of Jan. 16, 1879, when saying that "through the labours mainly of Berzelius and of Davy, the great generalization of electro-positive and electro-negative substances was established, and with it the fruitful theory of the electro-chemical exposition of compound bodies." Such of the experiments of Berzelius as were repeated by Sir Humphry Davy before the English Royal Institution, are embodied in Davy's paper (partly alluded to above in "Bakerian Lectures") which was read before the Royal Society, June 30, 1808. According to J. F. W. Herschel, Berzelius and Hisinger ascertained it as a general law, that in all of the chemical decompositions which they effected, the acids and oxygen become transferred to, and accumulated around, the positive pole, and hydrogen, alkaline earths and metals around the negative pole of a voltaic circuit; being transferred in an invisible, and, as it were, a latent or torpid state, by the action of the electric current, through considerable spaces, and even through large quantities of water or other liquid, again to reappear with all their properties at their appropriate resting-places.

Berzelius discovered selenium while examining certain substances found in the acid manufactured at Gripsholm, Sweden. He includes selenium among the metals; but as it is a non-conductor of electricity, also a most imperfect conductor of heat, and as, in other

respects, it bears much analogy to sulphur, it is generally placed among the non-metallic combustibles (Brande, "Manual of Chemistry," London, 1848, Vol. I. p. 435; Berzelius, "Lehrbuch der Chemie," "Traité," etc., Paris, 1846, Vol. II. p. 184; "Annales de Chimie et de Physique," Vol. IX. p. 160; "Annals of Philosophy," Vol. XIII. p. 401 and Vol. VIII, N.S. p. 104). The important rôle which the high electrical resistance of selenium has in its early days been made to play by Mr. Willoughby Smith, Dr. Werner Siemens and others, is alluded to at pp. 791–794 of Vol. IV supplement to "Ure's Dict. of Arts," etc., London, 1878.

For full accounts of Berzelius' numerous contributions to science, attention is called to the following:

References.—"Royal Society Catal. of Sc. Papers," Vol. I. pp. 330–341; "Gedächtnissrede auf Berzelius . . ." Berlin, 1851; G. Forchammer, "J. J. Berzelius," 1849; Poggendorff, Vol. I. pp. 172–175; "Afhandl. i Fisik. . . ."; Jos. Thomas, "Dict. of Biography," 1870, Vol. I. p. 341; "Report Smiths. Inst." for 1862, p. 380; "Vetensk. Acad. Handl."; "La Grande Encyclopédie," Vol. VI. p. 478. See likewise, "Journal Frankl. Inst.," 3rd Ser., Vol XVI. pp. 343–348; Faraday's "Experim. Researches," Arts., 746, 870, 960, and Vol. II. pp. 226–228; Gahn at p. 226 of Becquerel's "Eléments d'El. Ch.," Paris, 1843; "Annalen der Physik," Vol. XXVII. pp. 270, 311, 316, and Vol. XXXVI. p. 260; Gehlen's "Journal für die Chem. und Phys.," Vol. I. p. 115 and Vol. III. p. 177; John Black, "An Attempt . . . Electro-Chem. Theory," London, 1814; Gmelin's "Chemistry," Vol. I. pp. 400, 457–458, 461–462; "Encycl. Metrop." (Galvanism), Vol. IV. pp. 221–222; "Sc. Am. Suppl.," No. 284, p. 4523, for report of Helmholtz's Faraday Lecture of April 5, 1881, taken from the "Chemical News"; Sturgeon's "Annals," Vol. VII. pp. 300–303; Vol. VIII. p. 80; Whewell, "History of the Inductive Sciences," 1859, Vol. II. pp. 304, 347–348; Thos. Thomson, "An Outline of the Sciences . . ." London, 1830, Chap. XIV. p. 532; Berzelius and Wöhler on Volcanoes, in Poggendorff's "Annalen," Bd. I. s. 221, and Bd. XI. s. 146; "Journal des Savants" for June 1892, pp. 375–385; J. Berzelius and F. Wöhler, Leipzig, 1901; "Svenskt Biografiskt Handlexikon," Herm. Hofberg, Stockholm, pp. 88–89; "Bibl. Britan.," Vol. LI, 1812, pp. 174–183 ("Nicholson's Journal," July 1812) for John Gough's remarks on the hygrometer of Berzelius (Phil. Mag., Vol. XXXIII. p. 177); "Annales de Chimie," Vol. LI. pp. 167, 171; Vol. LXXXVI for 1813, p. 146; Vol. LXXXVII. pp. 286, etc.; also Vol. LXXIII. pp. 198, 200–201, the last named giving an account of the ammoniacal amalgam which Berzelius and Pontin were the first to explain.

A.D. 1802.—Thompson (Sir Benjamin), Count Rumford, an eminent scientist, native of Woburn in Massachusetts, Knt., F.R.S., one of the founders of the English Royal Institution, publishes his "Philosophical Memoirs . . . being a collection of . . . Experimental Investigations . . . of Natural Philosophy."

Though more properly identified with important observations and researches on heat, the question of the nature of which, Dr. Edward L. Youmans says, he was the first to take out of the domain of metaphysics, where it had stood since the days of Aristotle,

he has given accounts of some highly important experiments regarding the relative intensities and the chemical properties of light, heat and electricity, which can be seen at pp. 273, etc., Vol. LXXVI. part ii. of the *Phil. Trans.* for 1786. Heat spreads in every direction, whilst the electrical fluid may be arrested in its progress by certain bodies, which have on that account been called non-conductors, but he shows that the Torricellian vacuum affords, on the contrary, a ready passage to the electrical fluid while being a bad conductor of heat.

At p. 30 of George E. Ellis' "Memoir of Sir Benjamin Thompson," published in Boston (no date), is reproduced Rumford's "Account of what expense I have been at toward getting an electrical machine" during 1771, and at pp. 481–488, Vol. I, also pp. 350, 351, Vol. III of the "Complete Works of Count Rumford," published by the American Academy of Sciences, allusion is made to the galvanic influence in the construction of utensils.

REFERENCES.—Sir W. Thomson, "Mathematical and Physical Papers," London, 1890, Vol. III. pp. 123, 124; *Phil. Mag.*, Vol. IX for 1801, p. 315; Silliman's *American Journal of Science*, Vol. XXXIII. p. 21; "Biog. Universelle," Tome XXXVII. p. 81; "Journal des Savants," for Dec. 1881 and Jan. 1882; "Bibl. Britan.," Vol. LVI., 1814, pp. 398–401 (necrology).

A.D. 1802.—Pepys (William Haseldine, Sr.), son of an English manufacturer of surgical instruments, who became F.R.S. and was one of the founders of the Askesian Society, as well as of both the London Institution and of the London Geological Society, constructs, during the month of February 1802, the strongest pile hitherto known. It consists of sixty pairs of zinc and copper plates, each six feet square, held in two large troughs filled with thirty-two pounds of water containing two pounds of azotic, or nitric, acid.

It is said that with this battery he succeeded in melting iron wires ranging in diameter from one two-hundreth to one-tenth of an inch, the combustion developing an extremely bright light, while platinum wires, one thirty-second of an inch in diameter, turned to white heat and melted in globules at the point of contact. Charcoal was permanently ignited a length of nearly two inches and the galvanic action was strong enough to light it after passing through a circuit of sixteen persons holding one another by the hand. Gold leaf displayed a bright white light, accompanied with smoke; silver leaf gave an intense green light without sparks, but with still more smoke; while sheets of lead burned actively, with accompaniment of very red sparks mixed with the flame (Figuier, "Exposition," etc., Paris, 1857, Vol. IV. p. 347).

Later on, another battery was constructed by him for the

London Institution. This consisted of 400 pairs of plates five inches square, and of 40 pairs one foot square. With it, Davy ignited cotton, sulphur, resin, oil and ether, melted a platinum wire, burned several inches of an iron wire one three-hundredth of an inch in diameter, and boiled easily such liquids as oil and water, even decomposing and transforming them into gases. It was during the year 1808 that Pepys finished the enormous battery of 2000 double plates already alluded to under the Cruikshanks (A.D. 1800) and the Davy (A.D. 1801) articles, and which is to be found described at p. 110 of the "Elements of Chemical Philosophy."

One year before that (1807) Pepys constructed a new form of eudiometer, of which a description was given before the Royal Society on the 4th of June, as shown at p. 270 Vol. I of the "Abstracts of Papers," etc., of that Institution, as well as in the 1807 volume of the *Philosophical Transactions*.

Of the many ingenious experiments by which Pepys distinguished himself, scarcely none attracted more attention than those which are referred to in the last-named *Transactions* for 1866, pp. 339–439. It is only since 1815, when he employed the electric current to heat iron wire and diamond dust together, whereby he obtained steel, that the direct carburization of iron by the diamond has been clearly established. Prior to this date, during 1798, Clouet had melted a little crucible of iron weighing 57·8 grammes containing a diamond weighing 0·907 gramme, and produced a fused mass of steel. Guyton de Morveau reported upon Clouet's experiment in the *Annales de Chimie* for 1799 (Vol. XXXI. p. 328) and his investigations were repeated by many scientists, notably by Margueritte, as recently as 1865. The latter's observations, which were communicated to the *Annales de Chimie et de Physique* (Tome VI), showed that, although carburization can be effected by simple contact of carbon and iron in a gaseous atmosphere, it is nevertheless true that in the ordinary process of cementation the carbonic oxide gas plays an important part, which had until then been overlooked (Translation of Prof. W. C. Roberts-Austen, F.R.S. For Mr. Children's investigations in the same line, see the *Phil. Trans.* for 1815, p. 370, also A.D. 1809).

Sir Humphry Davy employed in his experiments on the decomposition and composition of the fixed alkalies two mercurial gasometers of Pepys' design, described in No. 14 of the *Phil. Trans.* for 1807, in conjunction with the same apparatus used by Messrs. Allen and Pepys for the combustion of the diamond ("Bakerian Lectures," London, 1840, pp. 84 and 93).

During the year 1822 Pepys constructed for electromagnetic experiments a very large spiral galvanic battery, which was put

together for the London Institution on the plan of the one first built by Dr. Robert Hare, Professor of Chemistry in the University of Pennsylvania. Pepys called it a *calorimotor*, by reason of its remarkable power of producing heat, and it is well illustrated in the 8th Edit. "Encyclopædia Britannica" article on "Voltaic Electricity." It consisted only of two metallic sheets, copper and zinc, fifty to sixty feet long by two feet wide, coiled around a cylinder of wood and prevented from coming together by three ropes of horse-hair, the whole being suspended over a tub of acid so that, by a pulley or otherwise, it could be immersed or taken up. As stated in Vol. V of the *Trans. of the Amer. Phil. Soc.*, this battery required nearly fifty-five gallons of fluid, and the solution used contained about one-fortieth of strong nitrous acid.

When, as Noad observes, it is stated that a piece of platinum wire may be heated to redness by a pair of plates only four inches long and two broad, the calorific power of such an arrangement as the above may be imagined to have been immense. The energy of the simple circle depends on the size of the plates, the intensity of the chemical action on the oxidizable metal, the rapidity of its oxidation, and the speedy removal of the oxide. Pouillet is said to have constructed one of these batteries with twelve couples for the Paris Faculté des Sciences, and found it very powerful in producing large quantities of electricity with low tension. The best liquid for this battery was water with one-fortieth in volume of sulphuric acid and one-sixtieth of nitric acid. With the above-described battery of Mr. Pepys, Sir Humphry Davy performed a remarkable experiment which is to be found described in the *Phil. Trans.* for 1823. A similar apparatus was produced independently, at about the same time, by Dr. Seebeck, of Berlin.

Another of Pepys' inventions is the substitution, for the tinfoil coatings within the glass of Bennet's electroscope, of two plates, forming an acute angle, which, by means of a regulating screw, can be adjusted to any required distance from the gold leaves. The angular part is secured to the bottom; the open part perpendicularly upward. By this mode of approximating the coatings to the gold leaves, the resistance being diminished, a weaker intensity of electricity suffices for their disturbance.

References.—*Quarterly Journal of Science*, Vol. I for 1816; *Phil. Mag.*, Vol. XXI. p. 241; XLI. p. 15; Becquerel, Vol. I. p. 34. Mr. William H. Pepys, Jr., published descriptions of the newly invented galvanometer and of the large galvanic apparatus in the *Phil. Mag.*, Vol. X., June 1801, p. 38, and Vol. XV for 1803, p. 94; "Cat. Sc. Papers Roy. Soc.," Vol. II. p. 192; "Bibl. Britan.," Vol. XVIII, 1801, p. 343, and Vol. XXII, 1803, p. 297.

A.D. 1803.—Geoffroy Saint-Hilaire (Etienne), a very eminent

French naturalist, once the pupil of Haüy, whose life he was the means of saving during the massacre of September 1792, is the first to give a thoroughly complete description of the electrical organs and functions of the *raia torpedo*, of the *gymnotus electricus*, of the *silurus electricus*, and of other similar species of fishes. His work on the subject, entitled "Sur l'anatomie comparée," etc., is alluded to in Vol. I. An. xi. No. 5 of the "Annales du Museum," whence it is translated for the fifteenth volume of the *Phil. Mag.*

His analyzation of the fluid in the cells of the *torpedo* showed it to consist of albumen and gelatine; and he discovered some organs analogous to those of the *torpedo* in different species of the same genus *raia*, which, strange to say, do not appear possessed of any electrical power.

The electrical organs of the *silurus electricus* he found to be much less complicated than those of other electrical fishes. They lie immediately below the skin and stretch all around the body of the animal. Their substance, he says, is a reticulated mass, the meshes of which are plainly visible, and these cells are filled, like those of other electrical fishes, with an albuminous gelatinous matter. The nerves distributed over the electrical organs proceed from the brain, and the two nerves of the eighth pair have a direction and nature peculiar to this species. (Consult C. Matteucci, "Traité des Phénomènes . . ." Paris, 1844, Chaps. VI and VII. pp. 301–327.)

In his great work on Egypt (Pl. XII, 2) Geoffroy gives the figure of a *malapterus electricus* (see Adanson, A.D. 1751) which is opened to show the viscera, but, by a singular inaccuracy, says Mr. James Wilson, the fish is represented as scaly, whereas there are no scales whatever upon this fish, and no fish known to possess electric powers has either scales or spines. The *torpedo*, the *gymnotus* and the *malapterus* have all naked skins. The *tetraodon electricus* (see Shaw at A.D. 1791) is also destitute of spines on the skin, although all its congeners have skins as bristly as those of a hedgehog.

Geoffroy Saint-Hilaire (Isidore), son of Etienne, was also a distinguished naturalist. He became Assistant Professor of Zoölogy to his father in 1829, likewise his assistant at the Faculté des Sciences in 1837, and, when Etienne became blind, during the year 1841, he succeeded to the Professorship of Zoölogy at the Museum of Natural History. He is the author of "The Life, Works and Theories (*Vie, Travaux et Doctrine*) of Etienne Geoffroy Saint-Hilaire," Paris, 1847.

REFERENCES.—Gilbert's *Annalen*, XIV. p. 397; *Bulletin Soc. Phil.*, No. 70; Geo. Wilson's "Life of Cavendish," London, 1851, p. 469, alluding to the later experiments on electrical fishes made by Faraday

(1838), Dr. James Stark, of Edinburgh (1844), Prof. Goodsir (1845), and Dr. C. Robin (1846). Consult also, *Journal de Physique*, Vol. LVI. p. 242, and the complete list of Geoffroy's works in Callisen's "Medicinisches-Schriftsteller Lexicon"; "Memoir of M. Isidore G. Saint Hilaire," by M. De Quatrefages, in "Report of Smithsonian Institution" for 1872, pp. 384–394; "Journal des Savants" for May–Aug., 1864; "Roy. Soc. Cat. of Sc. Papers," Vol. II. pp. 824–832; Vol. VI. p. 669; Vol. VII. p. 757.

A.D. 1803.—Carpue (J. C. S.), English scientist, relates, in his "Introduction to Electricity and Galvanism," published in London, some noteworthy experiments on the curative action of common electricity.

He repeated many of the investigations of Giovanni Aldini, and, in the presence of Dr. Pearson and other medical gentlemen, experimented upon the body of Michael Carney, immediately after his execution for murder. Carpue's main object was to ascertain whether galvanism, applied at once to the nerves, could excite action in the internal parts, and especially in the respiratory organs. He first made an opening into the windpipe and, after introducing about three pints of oxygen into the lungs, he applied conductors to the phrenic nerve as well as to other parts of the body, the lungs being at the same time occasionally inflated, but no action could be excited in the diaphragm. The application of conductors to the inside of the nostrils and elsewhere, however, excited very considerable contractions in the right auricle more than three hours after death, the ventricles being, as in Aldini's experiments, perfectly motionless.

References.—"Galvanic Experiments Made by Carpue on the Body of Michael Carney," etc., London, 1804 (*Phil. Mag.*, Vol. XVIII. p. 90); the "Encyclopedia Metropolitana," article "Galvanism," Vol. IV. pp. 105, 106, also the "Introduction," etc., above named for descriptions of Mr. Cuthbertson's plate electrical machine and of Mr. Read's condenser.

A.D. 1803.—Hachette (Jean Nicholas Pierre), a protégé of Monge, who became professor at the Paris Ecole Polytechnique, where he had among his pupils Poisson, Arago and Fresnel, presents to the Institut National the dry pile which was the result of the many experiments he had carried on in conjunction with Charles Bernard Desormes, who was then known as a prominent French scientist and manufacturer of chemical products.

Their idea was to establish the development of electricity by simple contact, and they sought to obtain a substance which would satisfactorily replace the wet discs, and not be affected by the metals, as had been all the liquids hitherto employed (H. Boissier, "Mémoire," etc., Paris, 1801). After numerous investigations they adopted a compound consisting of common starch and either

salts, varnishes or gums, with which they made the necessary discs. These discs were dried and placed alternately between the copper and zinc couples, but were afterward found to be too easily affected by moisture to prove very effective (D. Tommasi, "Traité des Piles Electriques," Paris, 1889, p. 529).

In the columns of the *Annales de Chimie*, named below, will be found detailed the numerous experiments with the galvanic pile carried on individually and collectively by Hachette, Desormes and other scientists; those of Hachette and Thénard upon the ignition of metallic wires claiming especial notice. Prof. John Farrar ("Elem. of Elec. Magn.," etc., Cambridge, 1826, p. 167) calls attention to the latter and in the *Phil. Mag.* for 1821 will be found an account of the researches of the above-named scientists made during the year 1805, to establish more properly the analogy between galvanism and magnetism. Hachette and Desormes endeavoured to ascertain the direction which would be taken by a voltaic pile, whose poles were not joined, when freely suspended horizontally. Their pile, as Fahie gives it, was composed of 1480 thin plates of copper tinned with zinc, of the diameter of a five-franc piece, and was placed upon a boat floating on the water of a large vat; but it assumed no determinate direction, although a magnetized steel bar, of a weight nearly equal to that of the pile, and likewise placed upon the boat, would turn, after some oscillations, into the magnetic meridian.

References.—*Annales de Chimie*, Vol. XXXVII. pp. 284–321; XLIV. pp. 267–284; XLVII (Biot's Observations), p. 13; XLIX. pp. 45–54, and XLV for 1808. See also, the *Annales* for 1834, as well as Vol. XLII. p. 125, for experiments of MM. Desormes and Clément on the fixed alkalies; *Journal de Physique* of Sept. 1820, for the paper of Hachette and Ampère on the electromagnetic experiments of Oersted and Ampère; *Annales de Chimie et de Physique*, Vol. II for May 1816, pp. 76–79, and V. p. 191; *Phil Mag.*, Vol. LVII. p. 43; L. W. Gilbert, *Annalen der Physik*, Vols. IX. pp. 18–39; XVII. pp. 414–427; *Journal de l'Ecole Polytechnique*, Vol. IV for 1802; XI. p. 284; Leithead, "Electricity," p. 252; *Bull. de la Soc. Philomathique*, No. 83; P. Sue, aîné, "Hist. du Galv.," Paris, An. X, 1802, Vol. II. pp. 160, 167, 188, 345 (Hachette et Thénard), and p. 371; Joseph Izarn, "Manuel du Galvanisme," An. XII, 1804, s. 4. p. 179; Poggendorff, Vol. I. pp. 562, 985; Larousse, "Dict. Universel," Vol. VI. p. 576; "Royal Society Catalogue of Scientific Papers," Vol. III. pp. 106–109.

A.D. 1803.—Biot (Jean Baptiste), who, in 1800, at the age of twenty-six, was made Professor of Natural Philosophy at the "Collège de France," and afterward ranked among the first astronomers and mathematicians, gives an account of his journey to Aigle, in the Department of l'Orne, whither he was sent by the Government to examine and report upon a very extraordinary shower of meteorites. The facts obtained by him were communicated to the Institute

on the 29th Messidor, An. XI, and also appeared at the time in the Paris *Journal des Débats* (*Phil. Mag.*, Vol. XVI. p. 299).

On the 23rd of August of the year following (1804) Biot accompanied Gay-Lussac in the latter's first memorable balloon ascent. This aeronautic voyage, sanctioned by the French Government mainly through the efforts of Berthollet and Laplace, was the first of the kind undertaken solely for a scientific object.

Besides numerous barometers and electrometers, Biot and Gay-Lussac carried with them two compasses, a dipping needle and other instruments. For the examination of the electricity of different strata of the atmosphere, they had several metallic wires from 60 to 300 feet in length, also a small electrophorus feebly charged, while for galvanic experiments they added some discs of copper and zinc, together with a supply of frogs, insects and birds. An account of the exceedingly important results obtained by those scientists at different elevations, of which the highest reached exceeded four miles, was read before the National Institute, Aug. 27, 1804. It was also published in London during the latter year, and alluded to at p. 371, Vol. XIX of the *Philosophical Magazine*. Mary Somerville remarks (" Connection of the Physical Sciences," 1846, p. 334) that according to the observations of Biot and Gay-Lussac, the magnetic action is not confined to the surface of the earth, but extends into space. The moon has become highly magnetic by induction, in consequence of her proximity to the earth, and because her greatest diameter always points toward it. Her influence on terrestrial magnetism is now ascertained; the magnetism of the hemisphere that is turned toward the earth attracts the pole of our needles that is turned toward the south and increases the magnetism of our hemisphere; and as the magnetic, like the gravitating force, extends through space, the induction of the sun, moon and planets must occasion perpetual variations in the intensity of terrestrial magnetism, by the continual changes in their relative positions.

In 1805 Biot published an investigation of the laws which should govern the dip and intensity, in the hypothesis of a magnet situated at the centre of the earth, having its poles infinitely close to each other and directed to opposite points on the surface of the globe and, as justly adds Major Edward Sabine (Report Seventh Meeting Brit. Asso.), it is a well-known consequence of this hypothesis that the lines of equal dip and equal intensity on the earth's surface should everywhere be parallel to each other. The phenomena of electricity had been brought within the pale of mixed mathematics by C. A. Coulomb (A.D. 1785), whose considerations mainly attached to the distribution of electricity upon the surface of spheres, and his investigations were at once diligently pursued by the French

scientists, Biot, Laplace and Poisson. Laplace, who undertook to investigate the distribution of electricity upon the surface of ellipsoids of revolution, showed that the thickness of the coating of the fluid at the pole was to its thickness at the equator as the equatorial is to the polar diameter, or, what is the same thing, that the repulsive force of the fluid, or its tension at the pole, is to that at the equator as the polar is to the equatorial axis. Biot extended this investigation to all spheroids differing little from a sphere, whatever may be the irregularity of their figure, and his solution of the problem will be found in No. 51 of the *Bulletin des Sciences*. He also determined, analytically, that the losses of electricity form a geometrical progression when the two surfaces of a jar or plate of coated glass are discharged by successive contacts, and he found that the same law regulated the discharge when a series of jars or plates are placed in communication with each other (Whewell, "History of the Inductive Sciences," Vol. II. pp. 208, 223; Noad's "Manual," p. 15; Eighth "Britannica," Vol. VIII. p. 531. For Biot's experiments, touching upon electrical attraction and demonstrating practically the distribution of electricity upon the surface of a conductor, see the last-named volume of the "Britannica," pp. 552, 556, and Noad, p. 56).

In conjunction with Frederick Cuvier, Mr. Biot investigated the connection of chemical charge with the production of electricity. Like Mr. W. H. Pepys, they examined the effect produced by the pile on the atmosphere in which it is located. Mr. Pepys placed the pile in an atmosphere of oxygen, and found that in the course of a night 200 cubic inches of the gas had been absorbed, but that in an atmosphere of azote the pile ceased to act. Biot and Cuvier likewise observed the quantity of oxygen absorbed, and inferred from their experiments that "although, strictly speaking, the evolution of electricity in the pile was produced by oxidation, the share which this had in producing the effects of the instrument bore no comparison with that which was due to the contact of the metals, the extremity of the series being in communication with the ground." Their investigation was attended by the discovery that as long as any oxygen remained to be absorbed, the chemical and physiological effects of the apparatus still continued, but with decreasing intensity; so that if the conducting wires attached to the two poles are made to return from under the receiver in tubes of glass they may be used to decompose water and communicate shocks to the organs. All these effects, however, cease when the surrounding oxygen is exhausted (*Annales de Chimie*, Vol. XXXIX. p. 242; *Soc. Philomathique*, An. IX. p. 40; Sue, "Histoire du Galv.," Vol. II. p. 161).

In the second volume of Biot's "Traité de Physique" will be found recorded his many observations on the nature and origin of the electric light, extracts from which are given by Sir David Brewster in the electricity article of the "Britannica." Biot remarks that the light which is observed during an electric explosion was for a long time considered by philosophers as a modification of the electric principle itself, which they supposed to be the quality of becoming luminous at a certain degree of accumulation (John Farrar, "Elem. of Elec., Mag. and El. Mag.," 1826, p. 118). Brewster adds that this eminent French writer, however, considered the opinion as erroneous, and he has devoted a whole chapter to prove that electricity has the same origin as the light disengaged from air by mechanical pressure, "and that it is purely the effect of the compression produced on the air by the explosion of electricity." In order to establish this theory, Mr. Biot has stated, on the authority of several experiments, "that the intensity of electric light depends always on the ratio which exists between the quantity of electricity transmitted and the resistance of the medium"; and he has shown, by an experiment with Kinnersley's thermometer, "that at each spark the air of the cylinder, driven by the repulsive force, presses on the surface of mercury, which rises suddenly in the small tube, and falls back again immediately after the explosion." He adds:

"This indication proves the separation produced between the particles of the mass of air where the electricity passes; and from what we know of its extreme velocity it is certain that the particles exposed immediately to its shock ought in the first moment to sustain individually all the effect of the compression. They ought, then, from this cause alone to disengage light, as when they are subjected to any other mechanical pressure. Thus one part at least of the electric light is necessarily due to this cause; and this being the case, there is no experiment which can lead us to conjecture that it is not all due to this cause."

References.—"Encycl. Brit.," 1857, Vol. XIV. pp. 7, 63, and *Journal de Physique*, Vol. LIX. p. 450. For Mr. Biot's observations on the magnetism of metals and minerals, and on the distribution of magnetism in artificial magnets, as well as for his improvement upon Coulomb's method of constructing the latter, see the last-named volume of the "Britannica," pp. 23, 26, 71, and Noad's "Manual of Electricity," London, 1859, pp. 528, 535, while, for Biot's very ingenious theory relative to the aurora, see Lardner and Walker's "Manual of Elec. Mag. and Meteor.," London, 1844, Vol. II. p. 235, and Noad, pp. 232, 233. The observations concerning the laws regulating the intensity of electromagnetic phenomena, made by MM. Biot and Savary, are alluded to by Noad at pp. 644, 645, in the "Encycl. Metropol." (Elec. Magn.), Vol. IV. p. 427; and Whewell's "History of the Inductive Sciences," 1859, Vol. II. pp. 245–249; "Scientific papers of the Royal Society," Vol. I. pp. 374–386; Biot's "Traité de Phys. Exp. et Math.," Vol. II. p. 457; *Journal de Physique*, Vol. LIX. pp. 315, 318; Wilkinson's "Elem.

of Galv.," Vol. II. pp. 38, 123, 154, 361, Chap. XVI; Humboldt's "Cosmos," treating of Aerolites, of the Zodiacal Light and of the figure of the earth; Noad, "Manual," p. 530; Eighth "Ency. Brit.," Vol. VIII. p. 580; Sir H. Davy, "Bakerian Lectures," London, 1840, p. 3, alluding to Biot and Thénard in No. 40 of the *Moniteur* for 1806; "Encycl. Metropol.," Vol. IV. (Electro-Magn.), p. 7; Harris "Rudim. Magn.," Part III, London, 1852, pp. 116, 117; Gautherot at A.D. 1801; Figuier, "Exposition," etc., Paris, 1857, Vol. iv. p. 429; "Lib. of Useful Knowl." (Electricity), p. 64 and (Magnetism), p. 89; "Soc. Philomath.," An. IX. p. 45; An. XI. pp. 120, 129; Becquerel's "Traité," 1856, Vol. III. p. 11; *Phil. Mag.*, Vols. XVI. p. 224; XXI. p. 362; "Mém. de l'Institut" for 1802, Vol. V; "Annales des Mines" for 1820, relative to the experiments on electro-magnetism made by Oersted, Arago, Ampère and Biot; *Phil. Mag.*, Vol. XXII. pp. 248, 249, for the magnetical observations made by Biot and Arago; *Comptes Rendus* for 1839, 1 Sem., VIII, No. 7, p. 233, for the observations of Biot and Becquerel on the nature of the radiation emanating from the electric spark; "Chemical News," London, 1868, Vol. XVI for John Tyndall's lecture on some experiments of Faraday, Biot and Savary; "Atti dell' Accad. dei Nuovi Lincei, Ann.," XV. Sess., IV. del 2 Marzo 1862, for the biography of J. B. Biot, who died Feb. 2, 1862, within two months of the completion of his eighty-eighth year. "Journal des Savants" for June and July 1820, April 1821, and for Feb.–Mar.–April 1846.

J. B. Biot's son, Edward Constant Biot (1803–1850), is the author of the extended catalogue of shooting stars and other meteors observed in China during twenty-four centuries, which was presented to the French Academy during 1841, and a supplement to which was published at Paris in 1848 (*Acad. des Sciences, Savants Etrangers*, Tome X).

A.D. 1803–1805.—Acting upon the discovery of Gautherot, the Bavarian philosopher Johann Wilhelm Ritter (1776–1810) is the first to construct an electrical accumulator.

Ritter's "ardency of research and originality of invention" had, as far back as 1796, shown itself in the numerous very able scientific papers relating to Electricity, Galvanism and Magnetism which he had communicated mainly through L. W. Gilbert's *Annalen der Physik*, J. H. Voigt's *Mag. für Naturkunde* and A. F. Gehlen's *Journal für die Chemie*, all which obtained recognition in several foreign publications. These papers secured for him membership in the Munich Academy during the year 1805.

From Prof. H. W. Dove's discourse before the Society for Scientific Lectures, of Berlin, the following is extracted:

"As the (then considered) essential portions of a galvanic circuit were two metals and a fluid, innumerable combinations were possible, from which the most suitable had to be chosen. This gigantic task was undertaken by Ritter, an inhabitant of a village near Leignitz, who almost sacrificed his senses to the investigation. He discovered the peculiar pile which bears his name, and opened

that wonderful circle of actions and reactions which, through the subsequent discoveries of Oersted, Faraday, Seebeck and Peltier, drew with ever-tightening band the isolated forces of nature into an organic whole. But he died early, as Günther did before him, exhausted by restless labour, sorrow and disordered living."

Ritter's *charging or secondary pile* consists of but one metal, the discs of which are separated by circular pieces of cloth, flannel or cardboard, moistened in a liquid which cannot chemically affect the metal. When the extremities are put in communication with the poles of an ordinary voltaic pile it becomes electrified and can be substituted for the latter; and it will retain the charge, so that for a time there can be obtained from it sparks, shocks, as well as the decomposition of water.

The writer of the article at p. 268 of the April 1802 *Monthly Magazine,* making reference to *an artificial magnet* discovered at Vienna (Bakewell, "Elec. Science," p. 40), no doubt alludes to the above-named charging or secondary pile, in the construction of which Ritter made many modifications. At first he arranged 32 copper and card discs in three series, two of which series contained 16 copper discs while the intermediate series consisted of 32 card discs. He then placed them so that the discs alternated, employing but 31 discs of copper, and he also used 64 as well as 128 copper discs alternating with similar ones of cardboard. In each case he compared the chemical action through the decomposition of water as well as the physiological effect or shock and the physical property or electrical tension. The results obtained are given in his many papers alluded to below.

Independently of the English scientists he discovered the property possessed by the voltaic pile of decomposing water as well as saline compounds, and of collecting oxygen and acids at the positive pole while hydrogen and the bases collect at the negative pole. He conceived that he had procured oxygen from water without hydrogen, by making sulphuric acid the medium of the communication at the negative surface, but, as Davy says, in this case sulphur is deposited, while the oxygen from the acid and the hydrogen from the water are respectively repelled, and the new combination produced.

A correspondent in Alex. Tilloch's *Philosophical Magazine* (Vol. XXIII for 1805–1806, pp. 51–54—Extracts from a letter of M. Christ. Bernoulli abridged from Van Mons' *Journal,* Vol. VI) thus alludes to some of Ritter's experiments communicated in May 1805 to the Munich Royal Society:

"I have seen him galvanize a louis d'or. He places it between two pieces of pasteboard thoroughly wetted, and keeps it six or eight minutes in the circuit of the pile. Thus it becomes charged,

though not immediately in contact with the conducting wires. If applied to the recently bared crural nerves of a frog the usual contractions ensue. I put a louis d'or thus galvanized into my pocket, and Ritter told me, some minutes after, that I might discover it from the rest by trying them in succession upon the frog. I made the trial, and actually distinguished, among several others, one in which only the exciting quality was evident. The charge is retained in proportion to the time that the coin has been in the circuit of the pile. Thus, of three different coins, which Ritter charged in my presence, none lost its charge under five minutes. A metal thus retaining the galvanic charge, though touched by the hand and other metals, shows that this communication of galvanic virtue has more affinity with magnetism than with electricity, and assigns to the galvanic fluid an intermediate rank between the two. Ritter can, in the way I have just described, charge at once any number of pieces. It is only necessary that the two extreme pieces of the number communicate with the pile through the intervention of wet pasteboards. It is with metallic discs charged in this manner and placed upon one another, with pieces of wet pasteboard alternately interposed, that he constructs his charging pile, which ought, in remembrance of its inventor, to be called the *Ritterian pile.* The construction of this pile shows that each metal galvanized in this way acquires polarity, as the needle does when touched with a magnet."

The same correspondent alludes to experiments made with Ritter's battery of 100 pairs of metallic plates, the latter having their edges turned up so as "to prevent the liquid pressed out from flowing away" (*Phil. Mag.*, Vol. XXIII. p. 51), but he says he was unable to see either Ritter's great battery of 2000 pieces, or the one of 50 pieces, each 36 inches square, the action of which is said to have continued very perceptibly for a fortnight. He writes as follows :

"After showing me his experiments on the different contractibility of various muscles ("Beiträge zur nähern Kenntniss," etc., Jena, 1802, B. II) Ritter made me observe that the piece of gold galvanized by communication with the pile exerts at once the action of two metals, or of one voltaic couple, and that the face which in the voltaic circuit was next the negative pole became positive, and the face toward the positive pole negative. Having discovered a way to galvanize metals, as iron is rendered magnetic, and having found that the galvanized metals always exhibit two poles as the magnetized needle does, Ritter suspended a galvanized gold needle on a pivot, and perceived that it had a certain dip and variation, or deflection, and that the angle of deviation was always

the same in all his experiments. It differed, however, from that of the magnetic needle, and it was the positive pole that always dipped."

It can truly be said that the nearest approach to a solution of the question as to the analogy between electric and magnetic forces, which had remained unsettled since the time of Van Swinden (see A.D. 1784), was given by Ritter, who announced "that a needle composed of silver and zinc arranged itself in the magnetic meridian and was slightly attracted and repelled by the poles of a magnet; that by placing a gold coin in the voltaic circuit, he had succeeded in giving to it positive and negative electric poles; that the polarity so communicated was retained by the gold after it had been in contact with other metals, and appeared therefore to partake of the nature of magnetism; that a gold needle under similar circumstances acquired still more decided magnetic properties; that a metallic wire, after being exposed to the voltaic current, took a direction N.E. and S.W." Dr. Roget gives these same extracts in his article on "Electro-Magnetism," and justly remarks that Ritter's speculations were of too crude a nature to throw any distinct light on the true connection between magnetism and electricity, nor was much notice taken of Ritter's announcements, owing to the vague manner in which they were made. No satisfactory results were in fact obtained until Oersted (at A.D. 1820) made his famous discovery which forms the basis of the science of electro-magnetism.

References.—The "Encyclopædia Britannica" article relating to the influence of magnetism on chemical action, for an account of Ritter's other experiments; also Faraday's "Experimental Researches," No. 1033; Ritter's "Physisch. Chem. Abhand.," etc., 3 vols., Leipzig, 1806; Poggendorff, Vol. II. p. 652; Tyndall's notes on Electric Polarization; Donovan's "Essay on the Origin, Progress and Present State of Galvanism," Dublin, 1816; "Société Philomathique," An. IV. p. 181; An. IX. p. 39; An. XI. pp. 128, 197; An. XII. p. 145; *Bull. Soc. Phil.*, Nos. 53, 76, 79; *Nuova Scelta d'Opus.*, Vol. I. pp. 201, 334; *Bibl. Brit.*, XXXI; "Reichsanzeiger," 1802, Bd. I, No. 66, and Bd. II, No. 194; also F. L. Augustin's "Versuch einer geschichte . . ." 1803, p. 75; Gilbert's *Annalen*, II, VI, VII, VIII, IX, XIII, XV, XVI; Voigt's *Magazin*, Vol. II. p. 356; Gehlen's *Journal*, Vol. III for 1804, and Vol. VI for 1806; "Denkschr. d. Münch.," 1808 and 1814; *Phil. Mag.*, Vol. XXIII. chap. ix. pp. 54, 55 (for experiments from Van Mons' *Journal*, No. 17), Vols. XXIV. p. 186; XXV. p. 368; LVIII. p. 43; L. F. F. Crell, "Chemische Annalen" for 1801; *Nicholson's Journal*, Vols. IV. p. 511; VI. p. 223; VII. p. 288, VIII. pp. 176, 184; "Gottling's Almanach" for 1801; Leithead, "Electricity," p. 255; "Encycl. Metropolitana," article "Galvanism," Vol. IV. p. 206; "Biographie Générale," Vol. XLII. p. 322; Larousse, "Dict. Universel," Vol. XIII. p. 1234; Pierre Sue, aîné, "Histoire du Galvanisme," Paris, An. X, 1802, Vol. I. pp. 226, 266; Vol. II. pp. 112–119, 156; Joseph Izarn, "Manuel du Galvanisme," Paris, An. XII, 1804, pp. 84–87, 249, 255–261; Brugnatelli, "Notizie . . . nell' anno 1804," Pavia, 1805, p. 16, also his *Annali di chimica*, Vol. XXII. p. 1; *Journal de Physique*, Vol. LVII. pp. 345, 406; *Annales de Chimie*, Vols. XLI. p. 208; LXIV. pp. 64–80; *Jour. de Chim. de Van*

Mons, No. 14, p. 212, for the experiments of Van Marum and Oersted, made with Ritter's apparatus; Sturgeon's "Scientific Researches," Bury, 1850, pp. 7, 8, and Prof. Millin's "Magazin Encyclopédique"; "Allgemeine Deutsche Biographie," Leipzig, 1875, Vol. XXVIII. pp. 675–678; "Bibl. Britan.," Vol. XXXI. 1806, p. 97, Vol. XXV. 1807, pp. 364–386 (Lettre de M. le Dr. Thouvenel).

A.D. 1803.—Basse (Fréderic Henri), of Hamel, makes one of the earliest trials of the transmission of galvanism through water and soil, the results of which appear in his work, "Galvanische Versuche," etc., published at Leipzig the year following.

Along the frozen water of the ditch or moat surrounding the town of Hamel he suspended, on fir posts, 500 feet of wire, at a height of six feet above the surface of the ice, then making two holes in the ice and dipping into them the ends of the wire, in the circuit of which were included a galvanic battery and a suitable electroscope, he found the current circulating freely. Similar experiments were made in the Weser; afterwards, with two wells, 21 feet deep and 200 feet apart; and, lastly, across a meadow 3000 to 4000 feet wide. Whenever the ground was dry it was only necessary to wet it in order to feel a shock sent through an insulated wire from the distant battery. Erman, of Berlin, in 1803, and Sömmering, of Munich, in 1811, performed like experiments, the one in the water of the Havel, near Potsdam, and the other along the river Isar.

Fahie, from whom we take the above, alludes to Gilbert's *Annalen der Physik*, Vol XIV. pp. 26 and 385, as well as to Hamel's "Historical Account," p. 17, of Cooke's reprint, and adds that Fechner, of Leipzig, after referring to Basse's and Erman's experiments in his "Lehrbuch des Galvanismus," p. 268, goes on to explain the conductibility of the earth in accordance with Ohm's law. As he immediately after alludes to the proposals for electric telegraphs, he has sometimes been credited with the knowledge of the fact that the earth could be used to complete the circuit in such cases. This, however, is not so, as we learn from a letter which Fechner addressed to Prof. Zetzsche, on the 19th of February 1872.

References.—Zetzsche's "Geschichte der ElektrischenTelegraphie," p. 19. See Dr. Turnbull's Lectures in the *Journal of the Franklin Institute*, Vol. XXI. pp. 273–274; "Scientific Papers of the Royal Society," Vol. I. p. 203.

A.D. 1803.—Thillaye-Platel (Antoine), French savant, who was afterward appointed pharmacist in the Paris *Hôtel-Dieu*, gives out as the result of numerous investigations a great many useful precepts on the medical application of electricity and galvanism, which will be found in his thesis presented to the Paris Ecole de Médecine on the 15th Floréal, An. XI. These precepts, De la Rive says ("Treatise on Elect.," translated by C. V. Walker, London, 1858,

Vol. III. pp. 587, 588), are followed to this day and are extremely simple, requiring only the use of metallic brushes held by an insulated handle and put into communication with the conductor of the machine; and directing the application of electricity in its mildest form as well as its gradual increase to as much as the invalid is able to support, besides allowing of the concurrent employment of other means acting in the same direction, such as frictions, blisters, etc.

Antoine Thillaye-Platel's uncle, Jean Baptiste Jacques Thillaye (1752–1822), French physician and Professor of Anatomy at Rouen and in Paris, published "Eléments de l'Elect. et du Galv.," Paris, 1816–1817, ten years after the death of his nephew (Poggendorff, Vol. II. p. 1094; Larousse, "Dict. Univ.," Vol. XV. p. 131).

De la Rive alludes to cures effected by several specialists and particularly to Father R. B. Fabre-Palaprat's translation made in 1828 of La Beaume's English work on the medical efficacy of electricity and galvanism, originally published in 1820–1826. The latter, he says, is preceded by a preface wherein the translator rivals the author on the wonderful effects of the electric fluid as a sovereign remedy for nearly all maladies.

References.—For M. Thillaye's experiments with M. Butet on galvanic electricity, made at the Paris Ecole de Médecine, see the *Bulletin des Sciences de la Soc. Philom.*, No. 43, Vendémiaire An. IX, also Vol. IX. p. 231, of the "Recueil Périodique de la Soc. Libre de Médecine du Louvre." Consult likewise, Poggendorff, Vol. II. p. 1094; "Royal Society Catalogue of Scientific Papers," Vol. V. p. 954; De la Rive's "Treatise," Vol. III. pp. 587, 588; P. Sue, aîné, "Histoire du Galvanisme," Vol. III. p. 14. Some of the other authors who have treated of the same subject are: F. Zwinger, 1697–1707; W. B. Nebel, 1719; Oppermanno, 1746; E. Sguario, 1746; G. C. Pivati, 1747–1750; G. Veratti, 1748–1750; O. de Villeneuve, 1748; L. Jallabert, 1748–1750; G. F. Bianchini, 1749; Mellarde, of Turin, 1749; Palma, 1749; F. Sauvages de la Croix, 1749–1760; J. B. Bohadsch, 1751; O. M. Pagani, 1751; S. T. Quellmaz, 1753; A. von Haller, 1753–1757; Linné (Linnæus), 1754; P. Paulsohn, 1754; E. F. Runeberg, 1757; P. Brydone, 1757; Lower, 1760; De Lassone, 1763; Wm. Watson, 1763; G. F. Hjotberg, 1765; J. G. Teske, 1765; P. A. Marrherr, 1766; Gardane, 1768–1778; J. G. Krunitz, 1769; R. Symes, 1771; Sigaud de la Fond, 1771; C. A. Gerhard, 1772; Abbé Sans, 1772–1778; J. Janin de Combe Blanche, 1773; J. B. Becket, 1773; Marrigues à Montfort L'Amaury, 1773; G. F. Gardini, 1774; J. G. Schaffer, 1776; Mauduyt, 1776–1786; De Thouri, 1777; A. A. Senft, 1778; Masars de Cazéles, 1780–1788; P. F. Nicolas, 1782; Bonnefoy, 1782; Niccolas, 1783; K. G. Kuhn, 1783, 1797; C. W. Hufeland, 1783; Cosnier, Maloet, Darcet, etc., 1783; J. P. Marat, 1784; G. Vivenzio, 1784; Carmoy, 1784–1785; G. Piccinelli, 1785; L. E. de Tressan, "Essai . . ." 1786, p. 233, etc.; Krunitz-Kirtz, 1787; Porna and Arnaud, 1787; F. Lowndes, 1787–1791; J. H. D. Petetin, 1787, 1808; G. Pickel, 1788; Van Troostwijk and Krayenhoff, 1788; R. W. D. Thorp, 1790; G. Wilkinson, 1792; C. H. Pfaff, 1793; G. Klein, 1794; M. Imhof, 1796; C. H. Wilkinson, 1799; C. A. Struve, 1802; Maurice, 1810; J. Morgan, 1815; Le Blanc, 1819; P. A. Pascalis, 1819; J. Price, 1821; K. Sundelin, 1822; Girardin, 1823; Ch. Bew, 1824; Sarlandière, 1825; S. G. Marianini, 1833; F. Puccinotti, 1834; François Magendie, 1836, 1837; Gourdon, 1838; C. Matteucci, Piria, etc., 1838, 1858; Breton Frères, 1844;

B. Mojon, Jr., 1845; J. E. Riadore, 1845; A. Restelli, 1846; Budge, 1846; F. Hollick, 1847; R. Froriep, 1850; C. V. Rauch, 1851; H. Valerius, 1852; Burci, 1852; Marie-Davy, 1852–1853; W. Gull, 1852; C. Beckensteiner, 1852–1870; F. Channing, 1852; F. F. Videt, 1853; R. M. Lawrance, 1853–1858; G. M. Cavalleri, 1854, 1857; Briand, 1854; M. Kierski, 1854; P. Zetzell, 1856; Ad. Becquerel, 1856–1860; E. Pfluger, 1856, 1858; Pulvermacher, 1856; P. C. Pinson, 1857; H. Ziemssen, 1857–1866; Philipeaux, 1857; J. Dropsy, 1857; M. Meyer, 1857–1869; Nivelet, 1860–1863; A. Tripier, 1861; J. Rosenthal, 1862; Desparquets, 1862; M. P. Poggioli (Mémoire lu à l'Institut, Oct. 31, 1853; " Annual of Scientific Disc.," 1865, p. 327); G. Niamias, " Della elettr. . . . medicina," 1851 (" An. of Sci. Disc.," 1865, p. 327); A. C. Garrat, 1866; H. Lobb, 1867; Aug. Beer, 1868; H. M. Collis (" An. of Sci. Dis.," 1869, p. 175); Toutain, 1870; J. R. Reynolds, 1872; Onimus and Legros, 1872; as well as Jobert de Lamballe, Richter and Erdmon, T. Guitard, J. J. Hemmer, H. van Holsbeek, T. Percival, J. D. Reuss and Mr. Ware (in Kuhn, Hist. II. p. 183).

A.D. 1803.—Berthollet (Claude Louis de), very eminent French scientist, who was the first of the leading chemists to openly endorse the antiphlogistic doctrine propounded by Lavoisier (A.D. 1781), and who with Laplace founded the well-known scientific Société d'Arcueil, admits in his " Essai de Statique Chimique " the analogy existing between caloric and the electric fluid. He believes that the latter during the oxidation of metals does not give out much heat, but causes only a dilatation of bodies which separates their molecules, and he also believes that electricity aids metallic oxidation by lessening cohesion (Delaunay, "Manuel de l'Electricité," p. 16).

When Berthollet and Charles passed heavy electrical charges through platinum wire, they observed that the latter acquired a temperature about equal to that of boiling water, and therefore not sufficient to fuse the wire. If the metal is one easily oxidized, the separation of the molecules causes them to unite with the oxygen of the air, and it is therefore the oxidation itself which produces the consequent high degree of heat.

References.—" Essai de Statique," Vol. I. pp. 209 and 263. See also " Biographie Générale," Vol. V. p. 716; Young's " Lectures," London, 1807, Vol. II. p. 423, and *Nicholson's Journal*, Vol. VIII. p. 80; Larousse, " Dict. Univ.," Vol. II. p. 617; " Sci. Papers of Roy. Soc.," Vol. I. pp. 321–323; Sir H. Davy, " Bakerian Lectures," London 1840, pp. 41, 94, regarding more particularly Berthollet's elaborate experiments on the decomposition of ammonia by electricity alluded to in *Mém. de l'Acad.*, 1782, p. 324, also Delaunay, " Manuel," pp. 17, 150.

A.D. 1804.—Jacotot (Pierre), Professor of Astronomy at the Lyceum of Dijon, states, at p. 223, Vol. I of his " Eléments de Physique Expérimentale," that Wlik, teacher of natural philosophy at Stockholm, invented the electrophorus during the year 1762. Jacotot, of course, refers to Johannes Carolus Wilcke (see A.D. 1757) who, during the month of August 1762, constructed a resinous apparatus to which he gave the name of *perpetual* electrophorus

(Scripta Academiæ Suec., 1762). Books V, VI and VII of the same volume treat respectively of Electricity, Galvanism and Magnetism.

References.—With regard to the *perpetual* electrophorus, see L. S. Jacquet de Malzet " Lettre d'un Abbé de Vienne . . ." Vienna, 1775, translated into German by " A. H." (A. Hildebrand), Wien, 1776; also C. Cuyper's " Exposé d'une méthode . . ." La Haye, 1778; and, for other improvements, Marsiglio Landriani, *Scelta d'Opuscoli*, 12mo, XIX. p. 73; J. F. Klinkosch, *Mém. de l'Acad. de Prague*, III. p. 218. Consult J. C. Poggendorff, " Biog.-Litter. Hand. . . ." Vol. I. pp. 1, 182, and Larousse, " Dictionnaire Universel," Vol. IX. p. 868.

A.D. 1804.—Hatchett (Charles), F.R.S. and foreign member of the Paris Academy, communicates through a paper entitled " An Analysis of the Magnetical Pyrites . . ." his conclusions that iron must be combined with a large portion of either carbon, phosphorus or sulphur in order to acquire the property of receiving permanent magnetic virtue, there being, however, a limit beyond which an excess of either of the above-named substances renders the compound wholly incapable of exhibiting the magnetic energy. In this connection, the interesting observations of Messrs. Seebeck, Chenevix and Dr. Matt. Young on anti-magnetic bodies, in Vol. XIV. p. 27, of the eighth " Encyclopædia Britannica," will repay perusal.

Three years before, on the 26th of November 1801, Mr. Hatchett had communicated to the Royal Society an interesting paper on *columbium*, a new metallic substance found in an ore from the State of Massachusetts.

References.—" Abstracts of the papers . . . of the *Phil. Trans.*," Vol. I. p. 155; also the *Phil. Trans.* for 1804, p. 315; *Phil. Mag.*, Vol. XXI. pp. 133 and 213; Poggendorff, Vol. I. p. 1031; " Cat. Sc. Papers Roy. Soc.," Vol. I. p. 155.

A.D. 1804.—M. Dyckhoff publishes in *Nicholson's Journal*, Vol. VII. pp. 303 and 305, " Experiments on the activity of a galvanic pile in which thin strata of air are substituted instead of the wet bodies." His description of what has by many been called the first practical dry pile is as follows :

" I constructed a pile with discs of copper and zinc, and little bits of thin green glass about the size of a lentil, three of which I placed triangularly in the intervals that separated the metallic plates. Thus between each pair of metals I had a thin stratum of air instead of a wet substance. A pile of ten pairs tried by the condenser affected the electrometer as powerfully as a common (voltaic) pile of five pairs."

It was in the year following, 1805, that Wilhelm Behrends, of Frankfort, constructed his dry pile consisting of eighty pairs of discs of copper, zinc and gilt paper (De la Rive, " Treatise on Electricity," Vol. II. p. 852).

The investigations of Maréchaux, De Luc, Zamboni and others in the same line will appear in due course.

References.—Young's "Lectures," London, 1807, Vol. II. p. 430, and *Nicholson's Journal*, Vol. VII. pp. 303 and 305, Becquerel, Paris, 1851, p. 34; Sturgeon's "Lectures on Galvanism," p. 73; Sturgeon's *Annals of Electricity*, Vol. VIII. pp. 378, etc.; *Journal de Chimie de Van Mons*, No. 11, p. 190, and also No. 12, p. 300, for Bouvier de Jodoigne's experiments; "Catalogue Scientific Papers of the Royal Society," Vol. II. p. 432; Gilbert, XIX. pp. 355–360, and Wilkinson's denial of the effectiveness of Dyckhoff's pile, in *Nicholson's Journal*, Vol. VIII. p. 1.

A.D. 1804.—Gay-Lussac (Joseph Louis), one of the most prominent of modern scientists, who was for a time assistant to Berthollet, makes, in Paris, two ascents in a balloon, at heights varying between 12,000 and 23,623 feet, for the purpose of carrying out extensive observations upon terrestrial magnetism. The latter are recorded at length in the *Journal de Physique*, Vol. LIX, and are alluded to in the articles "Aeronautics" and "Meteorology" of the "Encycl. Brit.," likewise at Biot, A.D. 1803, and in paragraphs 2961 and 2962 of Faraday's "Experimental Researches in Electricity," while at p. 193, Vol. XXI of the *Phil. Mag.* will be found the account of a very interesting aerial voyage made during January of the same year (1804) by M. Sacharof, of the St. Petersburg Academy of Sciences.

In conjunction with Louis Jacques Thénard (alluded to at Fourcroy, A.D. 1801), Gay-Lussac communicates to the *Annales de Chimie* for 1810 (Vol. LXXIII. p. 197, etc.), a paper relative to their "preparation of an ammoniacal amalgam through the agency of the voltaic pile" which had been read at the "Institut National" during the month of September 1809, and which is also alluded to at pp. 250, etc., of the *Annales de Chimie*, Vol. LXXVIII for 1811. Their united "physico-chemical researches on the voltaic pile . . ." are reviewed at pp. 243, etc., of the last-named volume and are likewise alluded to at p. 36 of Vol. LXXIX for the same year. The largest of the many piles they employed in their several experiments consisted of 600 pairs with a square surface of 1800 feet (Figuier, "Exposition et Histoire . . ." 1857, Vol. IV. pp. 387 and 433; *Journal des Mines*, Vol. XXX. pp. 5–56; Schweigger's *Journal*, Vol. II. pp. 409–423).

At pp. 76, etc., of the second volume of the *Annales de Chimie et de Physique* for the month of May 1816, are to be found the observations of Gay-Lussac on dry voltaic piles, especially upon those of Desormes et Hachette, De Luc and Zamboni. He remarks that the last named does not appear to have so constructed his pile as to enable the oscillations of the needle to indicate an exact measure of time (Schweigger's *Journal für Chemie*, Vol. XV. pp. 113, 130–132), but that the so-called electric clocks of M. Ramis, of

Munich, and of M. Streizig, of Verona, readily pointed the hours, minutes and seconds (Schweigger's *Journal*, Vol. XIII. p. 379; Ronalds' " Catalogue " for notices of his own as well as of the clocks of Ramis and of Streizig).

The investigations of Gay-Lussac and Humboldt, relative to the magnetic intensity and dip or inclination, throughout France, Germany, Switzerland and Italy, will be found recorded in the first volume of *Mém. d'Arcueil*, 1807, while at p. 284, Vol. X, and at pp. 305–309 of the *Annales de Chimie* are observations of Gay-Lussac and Arago, and at p. 509 of the fourth volume of Figuier's " Exposition et Histoire," etc., Paris, 1857, appears an extended account of the special report upon lightning rods, which Gay-Lussac was authorized by the Natural Philosophy Division of the French Academy of Sciences to prepare during the year 1823, and the outcome of which appears in the *Comptes Rendus des Séances* . . . Vol. XXXIX. p. 1142.

References.—Faraday's " Experimental Researches," 1839, Vol. I. p. 217, note, as well as paragraph No. 741 " Recherches Physico-chimiques," p. 12, and J. Farrar's " Elem. of Elec. Mag.," 1826, pp. 150–152; while for Gay-Lussac and Thénard's repetition of Sir Humphry Davy's experiments on the decomposition of the alkalies, see *Phil. Mag.*, Vol. XXXII. p. 88; " Instruction sur les parat . . ." for Gay-Lussac, Fresnel, Lefevre, Gineau and others, Paris, 1824, and for Gay-Lussac and Pouillet, Paris, 1855. Other reports on lightning rods not hitherto specially mentioned are: J. Langenbucher, 1783; Beyer, 1806–1809; P. Beltrami, 1823; Bourges, at Bordeaux, 1837; Boudin, 1855, and J. Bushee, Amer. Assoc., 1868. The observations of Thénard and Dulong are recorded at paragraphs 609, 612, 636, 637 of Faraday's " Experimental Researches," as well as at Vols. XXIII. p. 440; XXIV. pp. 380, 383 and 386 of the *Annales de Chimie*, and those of Thénard, Fourcroy, and Vauquelin will be found in the *Mém. des Soc. Sav. et Lit.*, Vol. I. p. 204. See " Royal Society Catalogue of Sc. Papers," Vol. II. pp. 800–807; Vol. V. pp. 944–948; Vol. VI. p. 666; Vol. VII. p. 748; Vol. VIII. p. 1072; " Discours de M. Becquerel . . ." *Inst. Nat. Acad. des Sciences ; Phil. Mag.*, Vols. XX. p. 83; XXI. p. 220; *Sci. Am. Supp.*, p. 11794; *Edin. Magazine*, Vol. V. p. 471; *Annales de Chimie et Physique* for 1818, Vol. VIII. pp. 68, 161, 163; the eighth " Britannica," Vol. VIII. pp. 532, 539, 573 for Gay-Lussac's additional experiments; the ninth " Britannica," Vol. X. pp. 122, etc.; also *Report Brit. Asso.*, London, 1838, pp. 7–8, for the magnetic observations of Gay-Lussac and Humboldt on the European Continent, likewise Sir Humphry Davy " Bakerian Lectures," London, 1840, pp. 134–137; Humboldt, at A.D. 1799, and Cruikshanks, at A.D. 1800. For a description of the Volta eudiometer invented by Gay-Lussac, see *Ann. de Ch. et Phys.*, Vol. IV. p. 188, also Dr. Hare in *Silliman's Journal*, Vol. II. p. 312, and for the " Memoir of Louis Jacques Thénard," by M. Flourens, see the " Report of the Smithsonian Institution " for 1862, pp. 372–383; " Journal des Savants " for Dec. 1850; Meyer's " Konversations-Lexikon " Leipzig und Wien, 1894, Vol. VII. pp. 140–141; " Dict. Général de Biog. et d'Histoire," Paris, 2nd ed., pp. 1218–1219.

A.D. 1805.—Mr. Joseph Davis submits to the London Society of Arts an improvement upon the telegraph of Lord George Murray

(A.D. 1795), consisting of the addition of a seventh shutter, which, instead of being poised on a horizontal axis, is made to slide up and down in grooves in the centre of the framework; so that it may either range with the six shutters or, if not required at all, may descend into a space provided for it in the roof of the Observatory. By this simple device the power of the apparatus is quadrupled, it being made capable of indicating in all 252 changes.

The night signals are given by a coloured lamp mounted in the centre of the seventh or sliding shutter and by six white lights fastened to the outside of the frame, to produce, through their display or concealment by slides, the same signals as, under ordinary circumstances, are given by the opening and closing of the shutters.

A.D. 1805.—Grotthus—Grothuss—(Theodor—more properly Christian Johann Dietrich, Baron von) makes known his theory of electro-chemical decompositions, through the "Mémoire," etc., published in 12mo at Rome, and of which an English translation appeared in London during 1806.

As Lardner and Fahie have it, Grotthus' theory was the most plausible of the many proposed at this early period of experimental inquiry to explain chemical decomposition by the voltaic apparatus. The above-named "Mémoire . . ." which appeared in the *Phil. Mag.* for 1806, Vol. XXV. pp. 330–334, is analyzed by both of these writers (Lardner, "Electricity, Mag. and Meteor.," Vol. I. pp. 135–137, or "Popular Lectures," 1851, Vol. I. pp. 348, 349; Fahie, "Hist. of Elec. Teleg.," pp. 210, 211), but it may be briefly stated in the words of Sir David Brewster as follows:

"Grotthus (*Annales de Chimie* for 1806, Vol. LVIII. p. 61) regards the pile as an electric magnet with *attracting* and *repelling* poles, the one attracting hydrogen and repelling oxygen, and the other attracting oxygen and repelling hydrogen. The force exerted upon each molecule of the body is supposed to be inversely as its distance from the poles, and a succession of decompositions and recompositions is supposed to exist among the intervening molecules."

In this connection it will be well to add here, by way of contrast, and again according to Sir David Brewster, the views held by other experimentalists of the same period. Sir Humphry Davy adopts the idea of attractions at the poles, diminishing to the middle or neutral points, and he thinks a succession of decompositions and recompositions probable. Messrs. Riffault and Chompré regard the negative current as collecting and carrying the acids on to the positive pole, and the positive current as doing the same, with the bases toward the negative pole. Biot attributes the effects to the opposite electrical states of the decomposing substances in the

vicinity of the two poles. M. De la Rive considers the portions decomposed to be those contiguous to both poles, the current from the positive pole combining with the hydrogen or the bases which are there present, and leaving the oxygen or acids at liberty, but carrying the substances in union with it across to the negative pole, where it is separated from them, entering the conducting metal, and leaving on its surface the hydrogen or its bases. Faraday regards the poles as exercising no specific action, but merely as surfaces or doors by which the electricity enters into or passes out of the substance undergoing decomposition. He supposes that "the effects are due to a modification of the electric current and the chemical affinity of the particles through or by which that current is passing, giving them the power of acting more forcibly in one direction than in another, and consequently making them travel by a series of successive decompositions and recompositions in opposite directions, and finally causing their repulsion or exclusion at the boundaries of the body under decomposition in the direction of the current, and that, in larger or smaller quantities, according as the current is more or less powerful."

In 1810 Grotthus published his "Uber d. elektricität . . . wassers entwickelt," one of his curious observations being the fact that when water is rapidly frozen in a Leyden jar, the outside coating, not being insulated, receives a weak electrical discharge, the inside being positive and the outside negative, and when the ice is rapidly thawed, the inside is negative and the outside positive.

References—Faraday's "Experimental Researches," articles 481, 485, 489, 492, 507, etc.; also *Phil. Mag.*, Vols. XXIV. p. 183, and XXVIII. pp. 35 and 59; Joseph Izarn, "Manuel du Galvanisme," pp. 280–284 for M. Riffault and N. M. Chompré; Whewell, "History of the Inductive Sciences," Vol. II. p. 304; Noad, "Manual," pp. 364, 365; William R. Grove, "On Grotthus' Theory . . ." London, 1845; J. S. C. Schweigger's *Journal*, Vols. III, IV, IX, XXVIII and XXXI; A. F. Gehlen's *Journal* for 1808; L. W. Gilbert's *Annalen der Physik*, Vol. LXVII; Ostwald, "Elektrochemie," 1896, pp. 309–316; A. N. Scherer's *Allgem. nördliche Annal. d. Chemie*, Vol. IV; *Annales de Chimie*, Vol. LXIII; *Phil. Mag.*, Vol. LIX. p. 67; J. C. Poggendorff, "Biog. Literarisches," etc., Vol. I. pp. 959, 960; "Royal Society Catalogue of Scientific Papers," Vol. III. pp. 29–31.

Grotthus' theory was extended by Rudolf Clausius, and the latter's theory in turn gave way to that of Svante Arrhénius. Clausius maintained that the exchanges were going on continuously, although no current was flowing; while the assumption of Arrhénius was that in every electrolyte, a certain number of molecules break up into ions and that all electrolytes contain some of these free ions. This is the much controverted dissociation theory (Dr. Henry S. Carhart's Presidential Address).

The "Encycl. Amer.," New York, 1903, Vol. II says that the establishment of the theory of electrolytic dissociation, which is due to the noted Swedish chemist, Svante Arrhénius, supplies a reasonable explanation of many chemical phenomena otherwise insoluble, and correlates various facts between which no connection was previously discovered. Two important publications by Arrhénius are "Sur la conductibilité galvanique des electrolytes" (1884), and a treatise in German on electro-chemistry (1902). (See "Le Moniteur Scientifique," Avril 1904, pp. 241–243.)

Rudolf Clausius, German scientist (1822–1888), "one of the most celebrated mathematical physicists of the nineteenth century," communicated in 1850 to the Berlin Academy of Sciences the paper wherein he announced the second law of thermo-dynamics, that "heat cannot of itself pass from a colder to a hotter body." The honour of establishing the science of thermo-dynamics upon a scientific basis he thus shares with Rankine and Thomson ("Encycl. Amer.," Vol. V. n. p.; "New Inter. Encycl.," New York, 1902, Vol. IV. p. 711. For biography, consult Riecke, "Rudolf Clausius," Göttingen, 1889; "Meyer's Konversations-Lexikon," Leipzig, 1894, Vol. IV. p. 213).

A.D. 1805.—Alexander Tilloch's *Philosophical Magazine*, Vol. XXI. p. 279, has a letter addressed by W. Peel to the editor, under date Cambridge, April 23, 1805, relative to the "Production of Muriate of Soda by the Galvanic Decomposition of Water." This is followed by a communication dated Pisa, May 9, 1805, from Dr. Francis G. Pacchiani, Professor of Philosophy at the Pisa University (Rees' Encyclopedia, "Galvanism," p. 15), to Lawrence Pignotti, Historiographer to the King, entitled "Formation of Muriatic Acid by Galvanism," as well as by two letters, one from W. Peel, dated Cambridge, June 4, 1805, on "The Production of Muriates by the Galvanic Decomposition of Water," and the other from Dr. Wm. Henry, dated Manchester, July, 23, 1805, relative to the above-named processes and to the latter's own experiments in the same direction.

REFERENCES.—*Phil. Mag.*, Vol. XXII. pp. 153, 179, 188; XXIII. p. 257; XXIV. p. 183; XXVII. p. 82; XXVIII. p. 306; Sir Humphry Davy's allusion to above, as well as his earlier experiments communicated to Dr. Beddoes, Sir James Hall, Mr. Clayfield and others, in "Bakerian Lectures," London, 1840, pp. 2, 3; Sylvester, at A.D. 1806, and Donovan, at A.D. 1812; Lardner's "Lectures on Science and Art," Vol. I. p. 350; Faraday's "Experimental Researches," No. 314; J. F. Macaire, *Ann. Ch. et Phys.*, XVII. 1821; Marni "Sulla formazione . . ."; G. B. Polcastro, "Giorm. Ital. Letter del Dal Rio," X. p. 182, 1805; Cioni and Petrini, *Phil. Mag.*, XXIV. 167, 1806; The Paris Galvani Society, *Phil. Mag.*, XXIV. p. 172, and *Ann. de Ch.*, Vol. LVI, 1806; A. B. Hortentz, *Phil.*

Mag., Vol. XXIV. p. 91, 1806; Leop. de Buch, *Phil. Mag.*, Vol. XXIV. p. 244, 1806; Veau Delaunay, *Phil. Mag.*, XXVII. p. 260, 1807; G. Innocenti, *Nuova Scelta d' Opuscoli*, II. p. 96, 1807; P. Alemanni, *Phil. Mag.*, Vol. XXVII. p. 339, 1807; C. H. Pfaff, *Phil. Mag.*, XXVII. p. 338, and XXIX. p. 19; *Ann. de Chim.*, Vols. LX. p. 314; LXII. p. 23, 1807–8; Wm. Henry, *Phil. Mag.*, Vols. XXII. p. 183; XL. p. 337, 1805–1812; F. G. Pacchiani, in *Nuova Scelta d' Opuscoli*, I. p. 277; Brugnatelli, *An. di Chimica*, Vol. XXII. pp. 125, 134 and 144; *Edin. Med. and Surg. Journal*, of July 1, 1805; *Phil. Mag.*, Vol. XXIV. p. 176, for his letter to Fabbroni. For Dr. Wm. Henry, consult "Bibl. Britan.," Vol. XV, An. VIII. pp. 35, 293; *Phil. Mag.*, Vols. VII for 1830, p. 228; XXII. p. 183; XXXII. p. 277, and XL. p. 337; *Phil. Trans.*, Part II for 1808.

A.D. 1806.—On Oct. 16, Mr. Wm. Skrimshire, Jr., addresses from Wisbech a letter to Mr. Cuthbertson on the absorption of electric light by different bodies.

In this letter, which is given in full at pp. 281–283 of the fifteenth volume of *Nicholson's Journal*, he says he was led to his experiments by the well-known fact that when the electric current is passed through a lump of sugar it makes the latter appear luminous. He tried many calcareous species, chalk, Kelton stone, the phosphate, nitrate, sulphates of lime, etc. etc., and he details some of the results obtained, the most interesting being that given by the sulphuret of lime, commonly called Canton's phosphorus, which, he says, is, by the electric explosion, rendered the most luminous of all the substances tried.

A.D. 1806.—Heidmann (J. A.), physician at Vienna, publishes his "Theorie der Galvanischen Electricität . . ." or "Theory of Galvanic Electricity deduced from Actual Experimentation" (London, 1807). This had been preceded by other important electrical reviews at Vienna during the years 1799, 1803 and 1804.

As stated by Guyton de Morveau, Heidmann has given us in the above the complete history of galvanic electricity—including the experiments and observations of Aldini, Arnim, Biot, Boeckman, Carminati, Cavallo, Creve, Davy, Fontana, Fowler, Gilbert, Haldane, Hallé, Helebrandt, Humboldt, Nicholson, Pepys, Pfaff, Reil, Reinhold, Ritter, Valli, Vassalli-Eandi, etc. etc.—together with the description of the construction and the relation of all parts of the galvanic pile, which is called by him a galvanic battery. Heidmann also gives an account of his many interesting experiments with frogs placed in different liquids as well as with the galvanic chain, and he reviews all the known phenomena presented by the voltaic pile.

References.—"Annales de Chimie," Vol. LXI. p. 70; *Phil. Mag.*, Vol. XXVIII. p. 97.

A.D. 1806.—Dr. Joseph Baronio of Milan constructs a gal-

vanic pile composed exclusively of vegetable substances. He makes his discs, two inches in diameter, of beet roots (*bietola rossa*) and of walnut wood (*legno di noce*), the latter having been freed from all of its resinous substance by treatment in a solution of vinegar and cream of tartar. Through this pile, he produced convulsions in a frog by excitation with a leaf of *cochlearia* (spoon wort or scurvy-grass).

References.—" Annales de Chimie," Vol. LVII. pp. 64–67; Vol. LXII. p. 212; *Phil. Mag.*, Vol. XXIII. p. 283; " Nota di Brugnatelli sopra una pila di sostanze vegetabili," Pavia, 1805 (" Am. di Chim. di Brugnatelli," Vol. XXII. p. 301); Volta, in *Giorn. Fis. Med.*, Vol. II. p. 122.

A.D. 1806.—Sylvester (Charles), the author of the articles on " Galvanism and Voltaism " in Rees' " Encyclopædia," announces that he obtains muriatic acid from pure water by passing through it the galvanic current. Mr. Wollaston, however, asserts this cannot be done unless the current traverses some vegetable or animal substance containing that acid.

His first paper on the subject appeared in *Nicholson's Journal*, 1806, Vol. XIV. pp. 94–98; in Gehlen's *Journ. der Chemie*, Vol. II for 1806, pp. 152–153, and in Gilbert's *Annalen der Physik*, Vol. XXV. pp. 107–112, 454–457. The paper following is entitled " Repetition of the Experiment in which Acids and Alkalies are Produced in Pure Water by Galvanism (no animal or vegetable matter, nor oxidable metal being present)."

References.—*Nicholson's Journal*, Vol. XV. pp. 50–52; Vol. XXIII. pp. 258–260; Gehlen's *Journal*, Vol. II, 1806, pp. 155–158. For his other papers, consult *Nicholson's Journal*, Vol. IX. p. 179; Vol. X. pp. 166–167; Vol. XIX. pp. 156–157; Vol. XXVI. pp. 72–75; Gilbert's *Annalen*, Vol. XXIII. pp. 441–447; " Roy. Soc. Catal. of Sc. Papers," Vol. V. pp. 900–901; Sturgeon's *Scientific Researches*, Bury, 1850, p. 153; Sir Humphry Davy's lecture " On some chemical agencies of electricity," read Nov. 20, 1806; *Annales de Chimie*, Vol. LX. p. 314; Vol. LXI. pp. 330–331; " Bibl. Britan.," Vol. XXXIII, 1806, p. 324.

A.D. 1806.—Maréchaux (Peter Ludwig), correspondent of the French Galvani Society at Wesel, is the first to construct an effective dry pile containing paper discs. He makes known through M. Riffault (*Annales de Chimie*, Vol. LVII for January 1806, p. 61), that water is not essential to the production of galvanic effects, and his experiments are repeated for the Chemical Society by M. Veau Delaunay, as shown in *Journal de Physique*, Messidor, An. XIV.

This " Maréchausian Pile," or *colonne pendule*, as it was originally denominated, consists of pairs of oven-dried cardboard, pasteboard, or blotting-paper, and of copper discs all pierced in such manner

as to be suspended by three silken cords which hold them fast in position. Sturgeon remarks ("Researches," pp. 199 and 239) that in this dry column the electric pulsations are, in consequence of the very great number of interrupting papers, less frequent than in either the processes of Volta or in that of Seebeck, notwithstanding which the instrument produces slow pulsatory currents.

References.—W. Sturgeon's "Annals of Electricity," Vol. I. p. 256, note; Vol. VIII. pp. 379, 484; *Phil. Mag.*, Vol. XXIV. p. 183; Poggendorff, Vol. II. p. 46; "Roy. Soc. Cat. of Sci. Papers," Vol. IV. p. 236; Gilbert's *Annalen der Physik*, Vols. X.–XXVII *passim*, also Vol. XV. p. 98 and Vol. XVI. p. 115 giving a description of the Maréchaux electromicrometer (screw and silver leaf), likewise Vol. XXII, containing an account of the observations made by M. Paul Erman.

A.D. 1807.—Young (Thomas), M.D., a very celebrated English scientist, "eminent alike in almost every department of human learning," who was the associate of Davy at the Royal Institution, and who became the successor of Volta as Foreign Associate of the French Academy of Sciences, publishes his very elaborate "Course of Lectures on Natural Philosophy and the Mechanical Arts," upon which he was assiduously engaged for five years, and a new edition of which was issued (with additional references and notes) by the Rev. P. Kelland, M.A., F.R.S., during the year 1845.

The above-named work comprises the sixty lectures which Dr. Young delivered during his connection with the Royal Institution and includes also his optical and other memoirs, as well as a very extended classified catalogue of publications in every leading department of science. His biographer in the "English Encyclopædia" remarks that Young's lectures embody a complete system of natural and mechanical philosophy, drawn from original sources, and are distinguished not only by extent of learning and accuracy of statement, but by the beauty and originality of the theoretical principles. One of these is the principle of interferences in the undulatory theory of light. "This discovery alone," says Sir John Herschel, "would have sufficed to have placed its author in the highest rank of scientific immortality, were even his other almost innumerable claims to such a distinction disregarded." The first reception, however, of Dr. Young's investigations of light was very unfavourable. The novel theory of undulation especially was attacked in the *Edinburgh Review*, and Dr. Young wrote a pamphlet in reply, of which it is said but one copy was sold, but it is now generally received in place of the molecular or emanatory theory.

His review and treatment of the field of electrical and magnetic phenomena, as may be imagined from the foregoing, is very

extensive, and as no justice could be done it by making therefrom such extracts as would suitably come within the scope of the present " Bibliographical History," only an extract from the lecture treating of " Aqueous and Igneous Meteors " will here be given.

Speaking of the aurora borealis, he says " that it is doubtful if its light may not be of an electrical nature. The phenomenon is certainly connected with the general cause of magnetism. The primitive beams of light are supposed to be at an elevation of at least 50 or 100 miles above the earth, and everywhere in a direction parallel to that of the dipping needle; but perhaps, although the substance is magnetical, the illumination, which renders it visible, may still be derived from the passage of electricity, at too great a distance to be discovered by any other test. . . . It is certainly in some measure a magnetical phenomenon; and if iron were the only substance capable of exhibiting magnetic effects, it would follow that some ferruginous particles must exist in the upper regions of the atmosphere. The light usually attending this magnetical meteor may possibly be derived from electricity, which may be the immediate cause of a change in the distribution of the magnetic fluid contained in the ferruginous vapours that are imagined to float in the air."

The assumption of ferruginous particles or vapours, remarks Prof. Robert Jameson, of the Edinburgh University, seems, however, purely gratuitous and imaginary; and as iron is not the only substance or matter capable of exhibiting magnetic effects, light itself being susceptible of polarization, the above hypothesis is, therefore, untenable even on the ground upon which it has been rested by its author. But it is, nevertheless, certain that the cause of this luminous meteor is intimately connected with magnetism and electricity; or, rather, as the magnetic is variously modified and effected by the electric power, with the phenomena of electro-magnetism.

References.—Young's Catalogue for " Aurora Borealis " and " Terrestrial Magnetism " (" Lectures," London, 1807, Vol. II. pp. 440–443, 488–490), " Journal Roy. Inst.," Vol. I; Dr. George Peacock's " Life of Thomas Young "; also " Miscellaneous Works of T. Young," London, 1855; " Memoirs of the Life of Thos. Young," London, 1831; also Vol. XIII of John Leitch's " Hieroglyphical Essays and Correspondence," all of which contain every contribution made by the scientist to the *Phil. Trans.*, as well as many other important articles communicated by him to other scientific publications of his time; " Eloge Historique de Dr. Thomas Young," par M. Arago, in *Mém. de l'Acad. Roy. des Sc.*, etc., Tome XIII. p. 57; *Quarterly Review* for April 1814; Tyndall, " Heat as a Mode of Motion," 1873, pp. 267, 268; *Annales de Chimie*, Feb. 1815; Whewell, " History of the Inductive Sciences," 1859, Vol. II. pp. 92, 96, 106, 111–118.

A.D. 1808.—Pasley (Charles William), F.R.S., D.C.L., K.C.B., who was at the time aide-de-camp to Sir John Moore, became Major-General in 1841 and Lieutenant-General in 1851, gives at pp. 205, 292, Vol. XXIX, and at p. 339, Vol. XXXV of Tilloch's *Philosophical Magazine*, a description of the original and improved methods of constructing his " polygrammatic telegraph."

The apparatus, as first devised by him between the years 1804 and 1807, consists of four posts, each bearing a pair of pivoted arms, which latter can be placed at different angles to indicate all desired numerals and letters. After he had seen the French semaphore during 1809 he improved his telegraph, employing but one post, upon which were three pairs of pivoted arms representing hundreds, tens and units.

In 1823 Pasley (then a Lieutenant-Colonel, Royal Engineers) issued a pamphlet entitled " Description of the Universal Telegraph for Day and Night Signals," wherein he announces the abandonment of the polygrammatic principle. For day service he employs an upright post with two movable arms attached to the top on a pivot. Each arm is capable of assuming seven different positions, besides the quiescent position called the *stop*, in which the arms are turned down and concealed by the post. To prevent signals being seen in reverse, another arm, called an *indicator*, is added to one side of the post. For night signals he places a central lamp at the top of the post, as well as a lamp at the end of each arm, and suspends a fourth lamp, as an indicator, upon a light crane projecting horizontally beyond the range of both movable arms. Motion to the arms was communicated by means of an endless chain passing over two pulleys. Up to this time the semaphores employed by the Admiralty had been constructed without provision being made for the display of night signals.

Pasley was the first to apply the heating power of the galvanic battery to a useful practical purpose. While engaged on the River Thames he was written to by Mr. Palmer (Alfred Smee, " Electro-Metallurgy," p. 297), who advised him to employ the galvanic battery instead of the long fuse then in common use, and as soon as he was made acquainted with the method of operating he at once adopted it and applied it effectively, during the year 1839, to the removal of the sunken hull of the " Royal George," at Spithead.

References.—Sturgeon's " Scientific Researches," Bury, 1850, p. 174; Knight's " Mech. Dict.," Vol. I. p. 784; also " Documents relatifs à l'emploi de l'Electricité," etc., Paris, 1841, taken from the *United Service Journal* and the " Militaire Spectateur Hollandais." Consult likewise, " Trans. of the Society . . . Arts," Vol. XXXIX, London, 1821, for

Peter Barlow, XL. pp. 76–100, and for Lieut. Nicolas Harris Nicolas, XL. p. 104; also Vol. XLII, London, 1824, for Mr. A. Westcott, pp. 165–166. A patented telegraph by James Boaz is alluded to in Vol. XII. pp. 84–87 of the *Phil. Magazine*.

Following close upon Pasley's original telegraphic contrivance were several other methods of conveying intelligence at a distance, introduced at this period, worthy of mention here.

The Chevalier A. N. Edelcrantz, Swedish savant, sent to the London Society of Arts a model of his apparatus, which is to be found minutely described in Vol. XXVI. pp. 20, 184–189, of the *Transactions* of that institution. A description of his earlier contrivances for the same purpose had already been published at Stockholm in the year 1796, and after being translated into French had been noticed in William Nicholson's *Journal of Natural Philosophy* for 1803. The one he finally adopted in 1808 consisted of ten boards placed in three vertical ranks, the central one having four boards and the side ranks three boards each. By this arrangement 1024 signals could be clearly shown, and it was possible, by observing the *order* in which the boards were exhibited, to make as many as 4,037,912 changes. He subsequently advised attaching lamps to the boards for night service. His system of working the boards, though very complicated, could be controlled by only one person, while the English method required several men to hold the shutters during heavy weather. As it was, his method is said to have been in constant use for fully twelve years prior to 1808 on both sides of the Baltic, and to have likewise served to transmit signals between Sweden and England.

Mr. Henry Ward, who had observed the difficulty with which the telegraph was worked at Blandford, in Dorsetshire, contrived the apparatus described in Vol. XXVI. pp. 20, 207–209 of the London *Journal of the Society of Arts*. The grooved wheels which are fixed upon the axis of the shutters to receive the ropes by which they are turned have the grooved portion of the rim formed in two segments, which are so attached to the periphery of the wheels by steel springs that they fly off and remain a little distance off when there is no strain upon the ropes, although so soon as a rope is pulled its pressure forces the segments into close contact with the solid rim of the wheel. In the segments are two notches, which, when the shutters are in either of their required positions, engage with a fixed catch so soon as the strain on the ropes is relaxed, and thus hold the shutters steady without any aid from the attendant. The pulling of a rope by drawing the segments close to the wheel releases the catch, and consequently enables the attendant to return any shutter to its original position.

Lieutenant-Colonel John Macdonald, F.R.S., who was already favourably known by two Reports on the Diurnal Variation of the Magnetic Needle observed at Fort Marlborough, Sumatra, and at St. Helena (*Philosophical Transactions* for 1796, p. 340, and for 1798, p. 397, also "Eighth Encycl. Brit.," Vol. XIV. p. 54), publishes (1808–1817) two treatises upon his "Terrestrial Telegraph," accompanied by an extensive "Telegraphic Dictionary." His contrivance consists of thirteen boards or shutters arranged, like those of Edelcrantz, into three vertical ranks representing hundreds, tens and units. Twelve of the boards are capable of producing 4095 distinct combinations, and the thirteenth or auxiliary board, which is mounted over the centre of the apparatus, doubles that number. A flag or vane is added to the hundred side to distinguish it in whatever direction it may be viewed, and a ball sliding upon the staff which supports it affords the means of again doubling the number, so that, on the whole, 16,380 distinct signals can be obtained. He subsequently adopted a modification of the contrivance introduced by Pasley in 1809, and also described a sort of a "Symbolic Telegraph," in which symbols like those of Dr. Hooke, but representing numerals instead of alphabetical characters, were dropped into open spaces denoting hundreds, tens and units. He further suggested a useful flag telegraph for the navy and devised several schemes for night telegraphs both for land and sea, one of which latter consists of three sets of four lights each, with an additional or *director* light to each set, affording the same extensive powers as his large board or shutter telegraph (*Phil. Mag.*, Vols. LVII. pp. 88–93, and LVIII. pp. 99–103).

Major Charles Le Hardy communicates in 1808 to the London Society of Arts, Vol. XXVI. pp. 20, 180–183, a novel contrivance consisting of a large framework with nine radiating bars, representing the numerals from 1 to 9, and four sets of other bars intersecting them so as to form four concentric polygons, which latter express units, tens, hundreds and thousands; thousands being shown by the innermost polygon. Attached to the centre of the apparatus are four slender arms, carrying four square boards, the lengths of these arms being such that the board of one may, during the revolution of the arm, traverse the polygon which represents thousands, that of another the polygon representing hundreds, etc. By the addition of two other boards at the upper corners, one of which denotes 10,000 and the other 20,000, or, when displayed together, 30,000, the total range of the telegraph is from 1 to 39,999 (*Philosophical Magazine*, Vol. XXXIII. p. 343).

In the twenty-seventh volume of the *Transactions* of the London Society of Arts will be found the telegraphic devices of Knight

Spencer and of Lieutenant James Spratt (pp. 20, 163–169), while the thirty-third volume contains (at pp. 23, 118–121) a description of the contrivance of Alexander Law, intended for service on both sea and land. These, it may be said, are the only additional telegraphic methods worthy of note introduced up to the time when the English Admiralty adopted the system proposed by Sir Home Popham in 1816. The "anthropo-telegraph" of Knight Spencer, though laid before the Society of Arts in 1808, had been used as early as 1805. It consisted merely of two circular discs of wicker work, painted white with a black circle in the centre, to be held in different positions with respect to each other. The device of Lieutenant Spratt was more simple still, for it consisted only in holding a kerchief in various positions; yet, simple as it was, it served as a means of communication between vessels before the battle of Trafalgar, and it was also successfully used to converse between Spithead and the ramparts at Portsmouth, etc.

References.—For Mr. Knight Spencer's other papers, see the *Philosophical Magazine*, Vols. XXXVI. p. 321, and XL. p. 206, and, for different methods of telegraphing, see Mr. Macdonald's "Treatise," published in 1817, as well as, more particularly, Vols. XXVI, XXXIV, XXXV, XXXVI of the *Transactions of the Society of Arts*; likewise Rohde's "Système complet de Signaux . . ." published 1835.

A.D. 1808.—Callender—Calendar (Elisha), of Boston, Mass., obtains, on Oct. 3, 1808, for his lightning rod, an American patent, which latter is the first one in the line of electricity issued by the United States.

References.—H. L. Ellsworth's "Digest of Patents," Washington, 1840, p. 234; Edmund Burke, "A List of Patents," Washington, 1847, p. 185; "List of United States Patents," Washington, 1872, p. 67.

A.D. 1808.—Bucholz (Christoph—Christian—Friedrich), distinguished German chemist, receives his diploma as a physician at Rinteln, prior to graduating at the Erfurt University, and publishes "Ueber die Chimischen . . . metallen," giving a description of the chain bearing his name. The latter was the result of experiments made by him to prove that the electricity in the pile results from the oxidation of one of the metals and also to establish a comparison between the quantity of electricity obtained and the amount of oxygen absorbed by the one metal.

References.—"Biographie Universelle," Bruxelles, 1843–1847, Vol. III. p. 227; A. F. Gehlen, *Jour. für Chem. und Phys.*, Vol. V; L. Figuier, "Exp. et Hist.," Paris, 1857, Vol. IV. p. 426; "La Grande Encyclopédie," Vol. VIII. p. 315, and also the letter of J. B. Van Mons to Bucholz, Brussels, 1810.

A.D. 1808.—Amoretti (Carlo), Italian naturalist, who was allowed (1772) to withdraw from the order of St. Augustine that he might devote himself exclusively to scientific researches, gives, in his "Della rabdomanzia ossia elettrometria," a complete history of the divining rod, and treats also therein of animal magnetism, etc. His investigations of the electric polarity of precious stones show, among other results, that the diamond, the garnet and the amethyst are — E, while the sapphire is + E.

REFERENCES.—For a further account of the *Virgula Divina*, or divining rod (*baguette divinatoire*), see the "Gentleman's Magazine" for 1751, Vol. XXI; also the notes at foot of pp. 91–106 of Baron Karl Von Reichenbach's "Physico-Physiologicæ Researches," translated by Dr. John Ashburner, London, 1851. In the latter, reference is made to Pierre Le Lorrain de Vallemont's "La Physique Occulte," etc. (1693), to a work written by Count J. de Tristan, to the "Mémoire," etc., of Tardy de Montravel (1781) and to Pierre Thouvenel's "Mémoires," etc., the last named bearing the Paris-London imprint of 1781–1784, and attempting to show relations existing between the rod and electricity and magnetism. Allusion is likewise made in the aforenamed work to the translation by Dr. Hutton (1803) of Jean Etienne Montucla's (1778) improvement of Jacques Ozanam's "Récréations Mathématiques et Physiques," originally built upon Leurechon's "Récréations Mathématiques," and first published in Paris during the year 1724. For Reichenbach, see "Le Cosmos," Nos. 703–705 for July 16, 23 and 30, 1898; "Cat. Sc. Pap. Roy. Soc.," Vol. I. pp. 139–140; Vol. VIII. pp. 720, 721. Besides the above, reference should be had to the lecture of Prof. Rossiter W. Raymond before the Philadelphia Electrical Exhibition of 1884, and to the article in Paris *Cosmos* of Jan. 3, 1891, which alludes to the works of P. Lebrun (1702), Albert Fortis (1802), Dr. Charpignon (1848), Abbé Chevalier (1853), and M. E. Chevreul "De la baguette . . ." (1854). Consult also, Eusebe Salverte, "The Philosophy of Magic.," Vol. II. chap. xi. speaking of Pryce's "Mineralogia Cornubiensis" (1778); Theod. Kirchmaier, "De Virgula divinatrice," 1678; F. Soave, (*Opus. Scelti*, III. p. 253), 1780; F. M. Stella (*Opus. Scelti*, XIII. p. 427), 1790; G. B. San Martino (*Opus. Scelti*, XVII. p. 243), 1794; L. Sementini, "Pensieri e Sperimenti . . ." 1811; A. M. Vassalli-Eandi (*Opus. Scelti*, XIX. pp. 215, etc.); Kiesser, *Archiv.*, Vol. IV. p. 62; at Vol. I. p. 265, of Blavatsky's "Isis Unveiled"; "Biographie Générale," Vol. II. pp. 290, 291; "Roy. Soc. Catal. of Sc. Papers," Vol. I. p. 58.

A.D. 1808.—Lebouvier-Desmortiers (Urbain René Thomas), French writer, who had called attention to the danger attending the bodily application of the galvanic fluid, through the *Journal de Physique* of 1801 (p. 467), transmits another Mémoire to the same publication upon an improved electrical (*briquet*) tinder box.

The cylinder, which had previously been made of copper, he constructed of glass as illustrated by Delaunay at Plate IX. fig. 105, of his "Manuel," etc., Paris, 1809. With the new contrivance he was enabled to exert considerable force upon the piston, and it was generally necessary to push the latter suddenly in order to so compress the air as to light the (*amadou*) spunk attached to the lower portion of the cylinder.

References.—See his "Examen des principaux systèmes . . ." Paris, 1813; J. C. Poggendorff, *Biogr. Liter. Hand* . . . Vol. I. p. 1399; Larousse, *Dict. Univ.*, Vol. X. p. 290; *Journal de Médecine*, Vol. XXVI. pp. 298–303; *Catal. Sc. Pap. Roy. Soc.*, Vol. III. p. 910; C. H. Wilkinson, "Elements of Galvanism," London, 1804, Vol. I. p. 461; V. Delaunay, "Manuel de l'Electricité," Paris, 1809, pp. 151–153; Detienne, "De l'électricité de pression" (*Journal de Physique*, 1777, Vol. IX).

A.D. 1809.—Krafft (Wolfgang Ludwig), Professor of Experimental Philosophy in the Imperial Academy of Sciences of St. Petersburg is the author of "Uber ein hypothet . . ." wherein is given the result of his investigations of the phenomena of terrestrial magnetism.

Comparing Biot's examination of the dip observations previously made by Humboldt, Krafft simplified the former's conclusions, showing that if we measure the latitude from the magnetic equator, the tangent of the dip is double the tangent of such latitude, or, as he expresses it: "If we suppose a circle circumscribed about the earth, having the two extremities of the magnetic axis for its poles, and if we consider this circle as a magnetic equator, the tangent of the dip of the needle, in any magnetic latitude, will be equal to double the tangent of this latitude."

Krafft gave a complete theory of the *electrophorus* in the first part of the 1778 "Acta Acad. Petrop.," which latter also contains his experiments with Canton's phosphorus and his observations on the aurora of February 6–17 of the same year. The results of many of his other investigations are to be found in Part XI of the work mentioned as well as in Vols. XV, XVII and XIX of the "Novi Commentarii Academiæ Petropolitanæ."

A.D. 1809.—Pinkerton (John), gives in his "Voyages and Travels," published at London (Vol. IV. pp. 1–76) a reprint of the rare volume entitled "Account of Paris at the close of the Seventeenth Century," by Martin Lister, M.D., wherein are detailed several surprisingly interesting experiments made by Mr. Butterfield with his wonderful collection of loadstones. It is therein stated that one of these loadstones, when unshod, weighed less than a dram and would suspend a dram and a half, but when shod would attract 144 drams of iron, whilst another of the loadstones, weighing 65 grains, attracted 14 ounces, or 140 times its own weight; another would work through a wall eighteen inches in thickness, etc. etc.

A.D. 1809.—Children (John George), an English scientist to whom reference has already been made, more particularly under Cruikshanks, A.D. 1800, communicates to the *Philosophical Transactions*, "An account of some experiments performed with a view to ascertain the most advantageous method of constructing a

voltaic apparatus for the purposes of chemical research." This paper appears also in Vol. XXXIV of the *Philosophical Magazine*.

Four years later (1813) he publishes a description of his magnificent galvanic battery, the largest ever constructed on the plan suggested by Dr. Wollaston. This consisted of twenty pairs of copper and zinc plates, each six feet long and two feet eight inches wide, the united capacities of the cells being 945 gallons. With this battery he confirmed Davy's observation that "intensity increases with the number (of plates) and the quantity of the electricity with the extent of surface." It is reported that, when in full action, the battery rendered a platinum wire five feet six inches long and $\frac{11}{100}$ of an inch in diameter red-hot throughout so as to be visible in full daylight; that eight feet six inches of platinum wire $\frac{44}{100}$ of an inch in diameter were easily heated red; that a bar of platinum one-sixth of an inch square and two and a quarter inches long was heated red-hot and fused at the end; and that a round bar of the same metal, $\frac{276}{1000}$ of an inch in diameter and two and a half inches long, was heated bright red throughout.

The result of many other investigations which he also made in 1813 and during 1815 showed that metallic wires (eight inches long and $\frac{1}{30}$ of an inch diameter) became red-hot in the following order: platinum, iron, copper, gold, zinc, silver; and he deduced that their conducting power was in the inverse order, silver conducting best and platinum least. Tin and lead fused immediately at the point of contact, and the oxides of tungsten, uranium, cerium, titanium, iridium and molybdenum were also fused. An opening made with a saw across an iron wire having been filled with diamond powder, the diamond was liquefied and the contiguous iron became steel. (See the Pepys entry at A.D. 1802.)

REFERENCES.—For Children's other experiments, consult "Phil. Mag.," Vol. XLII. p. 144; Vol. XLVI. pp. 409–415; *Phil. Trans.* for 1815, pp. 368–370, also Dr. Wm. Henry's "Elem. of Exper. Chem.," London, 1823, Vol. I. pp. 168–174; Dr. Thomas Thomson, "Outline of the Sciences," London, 1830, pp. 524–526; Louis Figuier, "Expos. et Hist . . ." Paris, 1857, Vol. IV. pp. 389–390; Becquerel, Vol. I. p. 52; "Encycl. Metrop.," Vol. IV. pp. 179, 222; Gmelin's "Chemistry," Vol. I. p. 424; "Cat. Sc. Papers Roy. Soc.," Vol. I. p. 317; Vol. II. p. 26; "Bibl. Britan.," Vol. XLIII, 1810, p. 67 and Vol. I of the N.S. for 1816, p. 109.

A.D. 1809–1810.—Oken (Lorenz)—originally Lorenz Ockenfuss—celebrated German naturalist, while occupying the post of Extraordinary Professor of Medicine at the University of Jena, publishes the great work "Lehrbuch der Naturphilosophie," which was translated into English by Dr. A. Tulk and published in London, during 1847, by the Royal Society, under the title of "Elements of Physico-Philosophy."

This work, says his biographer in the "English Cyclopædia" (Vol. IV. p. 557), takes the widest possible view of natural science: it is interesting as a document in the history of a great mental movement and contains the germs of those principles which are now regarded as the secure generalization of well-observed facts.

From the epitome of the work given in the "Encyclopædia Britannica," the following is extracted: "Polarity is the first force which appears in the world. . . . Galvanism is the principle of life . . . the vital force . . . the galvanic process is one with the vital process. . . . There is no other vital force than the galvanic polarity."

According to Dr. Richard Owen, Lorenz Oken contends that organism is galvanism residing in a thoroughly homogeneous mass. A galvanic pile, pounded into atoms, must become alive. In this manner, nature brings forth organic bodies. The basis of electricity is the air; of magnetism, metal; of chemism (the name he gives to the influence that produces chemical combination), salts. The basis of galvanism, in like manner, is the organic mass. Accordingly, whatever is organic is galvanic; whatever is alive is galvanic. Life, organism, galvanism, are one. Life is the vital process; the vital process is an organic or galvanic process. Galvanism is the basis of all the processes of the organic world. . . . God did not make man out of nothing, but took an elemental body then existing, an earth-clod or carbon, moulded it into form, thus making use of water, and breathed into it life, viz. air, whereby galvanism or the vital process arose. . . . Organization is produced by the co-operating process of light and heat. The ether imparts the substance, the heat the form, the light the life. . . . The life of an inorganic body is a threefold action of the three terrestrial elements, in which three processes galvanism consists. The nutrient process is magnetic, present and entire in every part of the body, and wheresoever it is withdrawn there is death. . . . These three processes constitute the galvanic process. Thus the galvanic circle is complete, and motion is the manipulation of galvanism. The process of motion is synonymous with the galvanic process—this is the vital process.

References.—The extended biography of Lorenz Oken, embracing a list of his chief works and original essays at pp. 498–503, Vol. XVI of the Eighth "Encycl. Britan."; Dr. William Whewell's "History of the Inductive Sciences," 1859, Vol. II. p. 477; "Hist. des Sciences," par F. L. M. Maupied, Paris, 1847, Vol. II. pp. 466–514.

A.D. 1809.—Luc (Jean André de), celebrated natural philosopher of Swiss extraction (though from 1773 until his death in 1817, a resident of England, where he became reader to Queen

Charlotte, the consort of George III), transmits to the Royal Society a long paper treating of the separation of the chemical from the electrical effects of the pile, with a description of the electric column and aerial electroscope.

In this communication, says Dr. Young, he advanced opinions so little in unison with the latest discoveries of the day, especially with those of the President of the Royal Society, that the Council probably thought it would be either encouraging error or leading to controversy to admit them into the *Philosophical Transactions.* He had, indeed, on other occasions shown somewhat too much scepticism in the rejection of new facts; and he had never been convinced even of Mr. Cavendish's all-important discovery of the composition of water.

The paper was afterwards published in *Nicholson's Journal* (Vol. XXVI), and the dry column described in it was constructed by various experimental philosophers. It exhibited a continual vibrating motion, made sensible by the sound of a little bell, which was struck by the pendulum at each alternation; and during many months the vibration was more or less rapid, according to circumstances affecting the column.

This dry column consists of discs of Dutch gilt paper, alternated with similar discs of laminated zinc, so arranged that the order of succession will be maintained throughout. When sufficiently dry these are piled upon each other, the gilt side of the paper being in contact with the zinc, and all are pressed together in a glass tube by a brass cap and screw connected at each end with a metallic wire. The column presented by De Luc to the Royal Society consisted of 300 discs of zinc and of 300 discs of gilt paper. It is said that with a larger column, the vibration of a brass ball suspended between two bells was so continued as to maintain a perpetual ringing for over two years; that with an apparatus comprising 20,000 groups of silver, zinc and double discs of writing paper, sparks have been obtained, while a Leyden jar was charged in ten minutes with sufficient electricity to produce shocks and to fuse an inch of platinum wire $\frac{1}{5000}$ of an inch in diameter; and that a similar pile, in the Clarendon Laboratory at Oxford, rang ten small bells continuously for over forty years.

In Vols. XXXV, XXXVI and XXXVII of the "Phil. Mag.," and in Vols. XXVII and XXVIII of "Nicholson's Journal," André de Luc shows how the dry column can be used for determining the insulating qualities and conducting power of bodies, it having been also employed as are aerial electroscopes to indicate the electrical changes taking place in the atmosphere. The other volumes of the same publications named below contain additional papers upon

electricity, galvanism, etc., while at p. 392, Vol. L of the *Phil. Mag.* will be found an account of De Luc's life and principal works, the latter being likewise mentioned in Vol. XXV of the "Biographie Universelle."

REFERENCES.—B. M. Forster, "Description . . . elec. col. . . . De Luc . . ." London, 1810; *Phil. Mag.*, Vol. XXXVII. p. 197; J. D. Maycock, *Phil. Mag.*, Vol. XLVIII. pp. 165, 255; L. Configliachi, "Osservazioni sulle pile a secco"; M. Delezenne, "Expériences sur les piles sèches"; *Bibl. Brit. Sci. et Arts*, Vol. XLVII, 1811, pp. 3, 113, 213, 313; Vol. XLIX, 1812, pp. 88–92 (Necrology of J. A. De Luc), Vol. L, 1812, p. 351 ("Nicholson's Journal," No. 126), also the "Bibl. Britan." for 1812, Vol. L. pp. 279–290 (Nicholson's *Journal*, April 1812), for J. D. Maycock's reply to De Luc's objections concerning voltaic plates ("Phil. Mag.," Vol. XLVIII. pp. 165, 255); Gmelin's "Chemistry," Vol. I. pp. 424–427; G. J. Singer's "Elements of Electricity" and William Sturgeon's *Annals of Electricity, passim*, as well as his "Researches," Bury, 1850, pp. 147, 199, 261; De la Rive's "Treatise on Electricity," Vol. II. p. 852; *Annales de Chimie et de Physique*, Vol. II. pp. 79–82 for May 1816; Gilbert's *Annalen*, Vol. XLIX; also Vols. VII, 1801, to Vol. LXXIV, 1821, for various articles upon the dry pile, etc.; G. Schübler, "Uber De Luc's Elektr. saüle . . ." 1813; Geo. Wilson's "Life of Cavendish," London, 1851, p. 66, etc.; "Nicholson's Journal," Vols. XXI, XXII, XXXII, XXXIII, XXXV; *Phil. Mag.*, Vols. XLII, XLV, the last named containing, at pp. 359–363, Mr. G. J. Singer's paper on "The Electric Column considered as . . . first mover for Mechanical Purposes," while at pp. 466, 467 is the communication of Mr. Francis Ronalds on De Luc's electric column. The latter is also specially referred to in Vols. XLIII. pp. 241, 363; XLVI. p. 11; XLVII. pp. 47, 48; XLVIII. pp. 165, 255; LVII. pp. 446, 447; while at p. 55 of Vol. XLIX is a paper relative to a "combination of the electric column, the thermometer, barometer and hygrometer in one instrument, for electro-atmospherical researches."

A.D. 1809.—Sömmering (Samuel Thomas von), German anatomist and physiologist, first employs voltaic, or contact, electricity for the transmission of telegraphic signals.

Both his original and perfected working instruments were constructed between July 9 and August 6, 1809 (*Journal Franklin Institute*, 1859, Vols. XXXVII and XXXVIII; *Journal Society of Arts*, Vol. VII. p. 235). The complete apparatus consists of thirty-five gold rods placed into glass tubes starting from a reservoir of acidulated water and connecting with thirty-five silk-covered wires, which are run into thirty-five apertures of copper (corresponding with twenty-five letters and ten figures) upon a wooden stand into each opening of which the wires of the voltaic pile can be inserted. When the latter are connected, the bubbles rising through the decomposition of the water are made to enter the lettered glass receivers through which the messages can be deciphered. On August 8, 1809, he was able to transmit intelligence a distance of 1000 feet, and twenty days later he presented his apparatus to the Bavarian Academy of Sciences (Fahie, "Hist. of Electric Telegraphy," p. 228).

Sömmering's telegraph was carried by Dominique Jean Larrey, chief surgeon of the French armies, to Paris, where it was delivered by him to the French Academy of Sciences, Dec. 5, 1809, and Dr. Hamel states that Biot, Carnot, Charles and Monge were appointed by that body to report upon the new invention (*Journal of the Franklin Institute* for 1859, Vol. XXXVIII. p. 398). In 1810 and 1811, Sömmering reduced the number of wires in his apparatus to twenty-seven. These brass or copper wires were first insulated with a covering of gum lac and then with silk thread, after which they were united into a thread-covered cable 1000 feet in length. The cable was in turn covered with heated gum lac or with a ribbon plunged in a solution of the same substance. The Russian Count Jeroslas Potocki took the new instrument to Vienna and submitted it, July 1, 1911, to the Emperor Francis I, while another model of the apparatus was sent to William Sömmering, then at Geneva, where it was shown to De la Rive, Auguste Pictet and other scientists. During March 1812 this instrument carried intelligence 10,000 feet, or ten times the distance previously reached.

REFERENCES.—Dr. Hamel, Cooke's reprint, pp. 7, 8. See Sömmering's own description of this, the first electro-chemical telegraph, in "Der Elektrische," etc., published by his son William at Frankfort, 1863, or the translations at p. 751 of Noad's "Manual," London, 1859, and at pp. 230–234 of Fahie's "Hist. of Elec. Tel.," London, 1884; Dr. Hamel, in *Jour. Soc. of Arts*, for 1859, p. 453, or the reprint of W. F. Cooke in 1859, Vol. VII. pp. 595–599 and 605–610; Du Moncel, "Exposé," etc., Vol. III; *Comptes Rendus*, Tome VII for 1838, p. 81; "De Bow's Review," Vol. XXV. p. 551; Highton's "Elec. Tel.," p. 39; Harris, "Galvanism," p. 35; Sturgeon's *Ann. of Elec.*, Vol. III, March 1839, pp. 447–448; "Turnbull, Electric Magn. Tel." "Denkschr. Münch. Akad. . . ." for 1809 and 1810, alluding to his first experimental instrument made in 1807; Schweigger, *Journal*, II. pp. 217, 240 of Vol. XX for 1817; Poggendorff's *Annalen*, Vol. CVII. pp. 644–647; "Smithsonian Report" for 1878, pp. 269–271; *Journal of the Franklin Institute* for 1851, Vol. XXI. pp. 330–332; Prime's "Life of Prof. Morse," 1875, pp. 263–275; "Bibl. Britan.," Vol. XLIX, 1812, p. 19; "Traité de tél. sous-marine," E. Wünschendorff, Paris, 1888.

A.D. 1810.—Prechtl (Johann Joseph), German mathematician and chemist, director of the School of Arts and Navigation in Trieste, also professor in the Vienna Polytechnic Institute, is the author of several very interesting articles on electricity, magnetism, etc., which appeared in Gilbert's *Ann. der Physik* from Vol. XXXV for 1810, to Vol. LXVIII for 1821, as well as in Gehlen's *Jour. für Chemie, Physik und Mineralogie*, Vols. V–VII. According to Figuier ("Expos. et Hist. . . ." 1857, Vol. IV. p. 433) we owe to Prof. Prechtl a still more lucid explanation of the theory of electric distribution and equilibrium in the voltaic pile than was conveyed even by the learned Prof. Jäger (A.D. 1802).

Of the many separate treatises which he wrote up to 1836, and which are contained in the numerous publications cited below, the most important, by far, is doubtless that treating of the fundamental state of the magnetic phenomena of the electrical connecting wire and on the transverse electrical charge ("Uber d. transversal-magnetismus . . .") which is to be found in Schweigger's *Journal für die Chemie und Physik,* Vol. XXXVI. pp. 399–410, and in Dr. Thomas Thomson's *Annals of Philosophy,* N.S., Article I. vol. iv. pp. 1–6 for July 1822. Alluding to the last named, Mr. Sturgeon says ("Scientific Researches," Bury, 1850, p. 29) that an *attempt* is made by M. Prechtl to explain the manner in which the connecting wire acts upon the needle, but that his diagrams and his mode of reasoning are too complex to be entered into the "Researches."

References.—Poggendorff's "Biograph.-Liter. . . ." Vol. II. pp. 519, 520; Larousse, "Dict. Univ.," Vol. XIII. p. 45; "Catal. Sc. Papers Roy. Soc.," Vol. V. pp. 3–5; Gehlen's *Journal,* Vols. VII. pp. 141–282; VIII. pp. 297–318; Gilbert's *Annalen,* Vols. XXXV, 1810, pp. 28–104; XLIV, 1813, pp. 108–111; LXVII, 1821, pp. 81–108, 221, 222, 259–276; LXVIII, 1821, pp. 104–106, 187–206; LXXVI, 1824, pp. 217–228; Brugnatelli's "Giornale," Vol. III, 1810, pp. 477–486; Kastner, "Archiv. Natur.," II, 1824, pp. 151–167; Wien, "Jahrb. Pol. Inst.," Vol. XIV, 1829, pp. 144–160, and Poggendorff's *Annalen der Physik und Chemie,* Vol. XV, 1829, pp. 223–238.

A.D. 1810.—The compiler of this "Bibliographical History" will doubtless be pardoned for introducing here an additional mode of "communicating intelligence" promptly at great distances. Reference is made to the first germ of pneumatic telegraphy sown by the English engineer, George Medhurst, during the year 1810.

The London *Telegraphic Journal,* which gives an extract from the specification of Medhurst's patent "for a new method of conveying letters and goods with great certainty and rapidity by air," states that the process took practical form only in 1854, when Latimer Clark laid down a one-and-a-half-inch lead pipe between the Electric Telegraph Company's central station, Lothbury, and the London Stock Exchange. The system was extended in 1858 to Mincing Lane, and, two years later, Varley introduced the use of compressed air, so that messages were drawn one way by a vacuum, and propelled in the opposite direction by a prenum, instead of employing a vacuum both ways, as Latimer Clark had previously done. During the year 1865 the system, then considerably modified, was introduced into Paris, and it was also made use of, at about the same time, by the Messrs. Siemens, who employed

it between the Bourse and the telegraph station in the city of Berlin.

A.D. 1810.—Jacopi (Joseph), Italian physician, anatomist and physiologist (1774–1813), pupil of the famous Scarpa, makes known through his " Elementi di Fisiologia e Notomia comparata " (" Eléments de Physiologie et d'Anatomie comparée "), the results of his very extended investigations of the electrical organs of the *torpedo*.

To him is due the first clear description of the electrical lobes situated in the *torpedo's* brain and of its relation to the eighth pair of nerves distributed throughout the hexagonal columns, which latter received also from him a very extended notice in the above-named work. The fifth ramification of nerves was first observed by Carus, and the most valuable investigation relative to the fourth and last important group of nerves directly connected with the electrical organs was made by the celebrated Italian professor, Carlo Matteucci.

REFERENCES.—Larousse, " Dict. Univ.," Vol. IX. p. 867; C. Matteucci, " Traité des Phénomènes Electro-Phys.," Paris, 1844, pp. 283–318; Geoffroy St. Hilaire at A.D. 1803.

Another author, Delle Chiaje, likewise gave a description of the rhomboidal sinus-shaped protuberance which he calls *lobo pagliarino* (straw-coloured lobe), and which he considers as formed of one mass but does not admit its important connection with the electrical organs.

A.D. 1811.—Poisson (Siméon Denis), a very able French scientist, communicates to the " Institut des Mathématiques et Physiques " and publishes at Paris under the caption " Traité de Mécanique," his analytical observations of the electric phenomena which, it has been truly said, actually establish a new branch of, and is the best elementary work extant upon, mathematical physics. One of his biographers remarks that Poisson's object was " to leave no branch of physics unexplored by aid of the new and powerful methods of investigation which a school, yet more modern than that of Lagrange and Laplace, had added to the pure mathematics."

As shown, notably by Sir David Brewster in his able article on " Electricity " in the eighth " Encycl. Brit." (Vol. VIII. p. 531), and by Noad, in his " Manual " (London, 1859, pp. 15, 16) :

" Poisson adopted as the basis of his investigations the theory of two fluids, proposed by Symmer and Dufay, with such modifications and additions as were suggested by the researches of Coulomb. He deduced theorems for determining the distribution of the electric fluid on the surfaces of two conducting spheres, when they are placed in contact or at any given distance, the truth of which had been established experimentally by Coulomb before the

theorems themselves had been investigated. On bodies of elongated forms, or those which have edges, corners or points, it is shown as a consequence of the theory of two fluids that the electric fluid accumulates in greater depths about the edges, corners or points than in other places. Its expansive force, being therefore greater at such parts than elsewhere, exceeds the atmospheric pressure and escapes, while at other points of the surface it is retained."

In the latter connection Mary Somerville remarks :

"There can hardly be a doubt but that all the phenomena of magnetism, like those of electricity, may be explained on the hypothesis of one ethereal fluid, which is condensed or redundant in the positive pole, and deficient in the negative; a theory that accords best with the simplicity and general nature of the laws of creation; nevertheless, Poisson has adopted the hypothesis of two extremely rare fluids, pervading all the particles of iron, and incapable of leaving them. Whether the particles of these fluids are coincident with the molecules of the iron, or that they only fill the interstices between them, is unknown and immaterial. But it is certain that the sum of all the magnetic molecules, added to the sum of all the spaces between them, whether occupied by matter or not, must be equal to the whole volume of the magnetic body. . . . M. Poisson has proved that the result of the action of all the magnetic elements of a magnetized body is a force equivalent to the action of a very thin stratum covering the whole surface of a body, and consisting of the two fluids—the austral and the boreal, occupying different parts of it; in other words, the attractions and repulsions externally exerted by a magnet are exactly the same as if they proceeded from a very thin stratum of each fluid occupying the surface only, both fluids being in equal quantities, and so distributed that their total action upon all the points in the interior of the body is equal to nothing. Since the resulting force is the difference of the two polarities, its intensity must be greatly inferior to that of either" (J. C. Wilcke at A.D. 1757, "Conn. of the Phys. Sci.," 1846, s. 30 pp. 308, 309).

The "Mémoires de l'Institut" for 1811 contain Poisson's very able papers showing the manner in which electricity is distributed on the surfaces of bodies of various figures and the thickness of the stratum of electricity existing throughout these bodies. Mrs. Somerville further observes of work already cited (s. 28) :

"Although the distribution of the electric fluid has employed the eminent analytical talents of M. Poisson and M. Ivory, and though many of their computed phenomena have been confirmed by observation, yet recent experiments show that the subject is

still involved in much difficulty. Electricity is entirely confined to the surface of bodies; or, if it does penetrate their substance, the depth is inappreciable; so that the quantity bodies are capable of receiving does not follow the proportion of their bulk, but depends principally upon the form and extent of surface over which it is spread; thus the exterior may be positively or negatively electric, while the interior is in a state of perfect neutrality." (Consult J. Farrar, "Elem. of Elect. Magn. and Electro-Magn.," 1826, pp. 50–56.)

In his treatment of the theories of magnetism, Brewster alludes again to the masterly investigations of Poisson, who, says he, appears to have been "the first to conceive the idea of absolute magnetic measurement." In a short but luminous article at the end of the "Connaissance des Temps" for 1828, he describes the method for obtaining the value of H in absolute measure. His first and second "Mémoire sur la Théorie du Magnétisme" appeared during 1824–1825, at pp. 247, 488, Vol. V of the *Transactions* of the Paris Royal Academy, and were closely followed (Vol. VI. p. 441) by his Memoir on the theory of Magnetism in motion. Translations of these will be found at pp. 336–358, 373, Vol. I and pp. 328–330, Vol. V of the *Edin. Jour. of Sci.* and at pp. 334, 335 of John Farrar's "Elem. of Elect. Magn. and Electro-Mag.," all published during the year 1826.

Poisson's theoretical prediction of magne-crystallic action is thus alluded to by Dr. John Tyndall in his "Researches on Diamagnetism," etc., London, 1870, pp. 13 and 66, 67:

"In March 1851, Professor William Thomson (Lord Kelvin) drew attention to an exceedingly remarkable instance of theoretic foresight on the part of Poisson, with reference to the possibility of magne-crystallic action.

"Poisson," says Sir William, "in his mathematical theory of magnetic induction founded on the hypothesis of magnetic fluids (moving within the infinitely small magnetic elements), of which he assumes magnetizable matter to be constituted, does not overlook the possibility of those magnetic elements being non-spherical and symmetrically arranged in crystalline matter, and he remarks that a finite spherical portion of such a substance would, when in the neighbourhood of a magnet, act differently according to the different positions into which it might be turned with its centre tube fixed. But (such a circumstance not having yet been observed), he excludes the consideration of the structure which would lead to it from his researches, and confines himself in his theory of magnetic induction to the case of matter consisting either of spherical magnetic elements or of non-symmetrically disposed elements of any forms.

Now, however, when a recent discovery of Plucker's has established the very circumstance, the observation of which was wanting to induce Poisson to enter upon a full treatment of the subject, the importance of working out a magnetical theory of magnetic induction is obvious.

"Sir William Thomson then proceeds to make the necessary 'extension of Poisson's Mathematical Theory of Magnetic Induction,' and he publishes a striking quotation from the 'Mémoires de l'Institut,' 1821–1822, Paris, 1826."

References.—Biography in "English Encycl.," Vol. IV. p. 899; *Phil. Mag.* for 1851; Roy. Soc. Catal. of Sci. Papers, Vol. IV. pp. 964–969; G. M. Racagni, "Sopra una Memoria . . ." 1839; Johnson's "Encycl.," 1878, Vol. III. p. 227; eighth "Britannica," Vol. XV. p. 98; ninth "Britannica," Vol. XV. pp. 241, 249; *Ann. de Chimie* for Feb. 1824; "Le Globe," No. 87; Harris, "Magnetism," p. 131; Whewell, "Hist. of the Inductive Sciences," 1859, Vol. II. pp. 43, 208, 209, 222, 223; Sir William Thomson's works, 1872; Thomas Thomson, "An Outline," etc., 1830, p. 351; *Mém. de l'Acad. des Sci.* for 1824–1826, 1838; *Soc. Philom.* for 1803, 1824–1826; Humboldt's "Cosmos," London, 1849, Vol. I. pp. 104, 105, 130, 165–169; N. Bowditch, "Of a mistake which exists in the calculation of M. Poisson relative to the distribution of the electric matter upon the surfaces of two globes, in Vol. XII of the "Mém. . . . Sc. Math. . . . de France"; *Mem. Amer. Acad.*, O.S., Vol. IV. part i. p. 307; Houzeau et Lancaster, "Bibl. Gén.," Vol. II. p. 228. Mention is made of Poisson's principal writings, in Vol. XI. pp. 179–191 of M. Max Marie's "Hist. des Sciences Mathém.," Paris, 1888, but the complete list will be found in Vol. II of the works of Arago.

A.D. 1811.—Schweigger (Johann Salomo Christoph), a chemist of Halle (1779–1857), inserts at p. 240, Vol. II of his *Journal für dic Chemie und Physik*, the memoir of Sömmering, relative to his electro-chemical telegraph, as well as an appendix thereto, wherein he points out the difficulties likely to attend the employment of so many different wires. He suggests the use of but two wires, and of two piles of unequal power. With these, all desired characters could be transmitted, through a preconcerted code regarding the meaning of such letters and figures as would be represented by the weaker or the stronger pile, in conjunction with the duration of the gas evolutions or the space of time separating them. He also suggested, for an alarum, the use of a pistol, by connecting a battery to the pile, in lieu of liberating an alarm by means of accumulated gas as Sömmering had done.

Two months after Oersted's great discovery, which was announced in July 1820, Schweigger read at Halle (September 16, 1820) and communicated to the German *Literary Gazette* (No. 296 for November 1820), a paper relative to an important improvement made in his *galvano magnetic indicator*. The latter, which had been described at pp. 206–208 of Gehlen's (1808) *Journal für Chemie*,

was merely an electroscope, employed to indicate the attraction and repulsion of ordinary frictional electricity in lieu of a Coulomb balance, the improved apparatus being the result of his discovery that, by coiling an *insulated* wire several times around a magnetic needle, the deflecting power of the voltaic current increases with the number of turns (Kuhn, "Ang. Elek.-Lehre," p. 514).

Alluding to Schweigger's multiplier, the Abbé Moigno says:

"A conducting wire twisted upon itself and forming one hundred turns will, when traversed by the same current, produce an effect one hundred times greater than a wire with a single turn: provided always that the electric fluid pass through circumvolutions of the wire without passing laterally from one contour to another" (*Cornhill Magazine*, Vol. II for 1860, pp. 61, 64).

It was, however, shown by Dr. Seebeck that the power of multiplication does not increase with the number of windings in the uniting wire, for the resistance to transmission naturally increases with the length of the wire, thus diminishing its conducting power.

To his new instrument Schweigger gave the name of *electro-magnetic multiplier* (*multiplicator*) or *galvanometer multiplier*, and it has become the most important for indicating and measuring the strength of the galvanic current.

Prof. W. B. Rogers says that Schweigger's apparatus as improved by Nobili (*Ital. Soc. Mem.*, Vol. XX. p. 173) became indispensable in the measurement of current electricity, and that through the later improvements given it by Sir William Thomson (also by Du Bois Reymond), it has been made one of the most perfect and delicate of all known means of measuring force. Schweigger's multipliers with improvements made thereon by Oersted and Nobili are illustrated at p. 642, Vol. XXI of the eighth "Ency. Britannica," where reference is made to drawings on a large scale shown at Plate 522, article "Thermo-Electricity," of the "Edinburgh Encyclopædia."

According to a footnote, p. 273 of "Report Smithsonian Inst." for 1878, Schweigger's multiplier is alluded to in the "Additions to Oersted's Electromagnetic Experiments," a memoir read at the *Naturforschende Gesellschaft* at Halle, September 16 and November 4, 1820. An abstract of this paper was published in the *Allgemeine Literatur-Zeitung* of Halle (4to), November 1820, No. 296, Vol. III. col. 621–624, whilst the full memoir appeared in the *Journal für Chemie und Physik*, 1821, Vol. XXXI. pp. 1–17; and "Additional Remarks . . ." by Dr. Schweigger, in the same volume, pp. 35–41. It is further stated in the aforementioned note that:

"A galvanometer of somewhat different form, having a vertical

helix and employing an unmagnetized needle, was very shortly afterward independently devised by Johann Christian Poggendorff, of Berlin; and as he preceded Schweigger in publishing an account of it, he is sometimes regarded as the original inventor. Schweigger designated his device an 'Electromagnetic Multiplicator'; Poggendorff designated his arrangement a 'Galvano-magnetic Condensator.' Prof. Oersted remarks: 'Immediately after the discovery of electromagnetism, M. Schweigger, professor at Halle, invented an apparatus admirably adapted for exhibiting by means of the magnetic needle the feeblest electric currents. . . . M. Poggendorff, a distinguished young savant, of Berlin, constructed an electromagnetic multiplier very shortly after M. Schweigger, with which he made some striking experiments. M. Poggendorff's work having been cited in a book on electromagnetism by the celebrated M. Erman (published immediately after the discovery of these phenomena), became known to several philosophers before that of M. Schweigger' (*Annales de Chimie et de Physique,* 1823, Vol. XXII. pp. 358–360).

"The researches of Schweigger and Bart leave us little or no doubt that the ancients were well acquainted with the mutual attraction of iron and the lodestone, as well as with the positive and negative properties of electricity, by whatever name they may have called it. The reciprocal magnetic relations to the planetary orbs, which are all magnets, was with them an accepted fact, and aerolites were not only called by them magnetic stones, but used in the Mysteries for purposes to which we now apply the magnet."

References.—"Isis Unveiled," Vol. I. pp. 281, 282. See also *Annales de Chimie et de Physique,* 1816, Vol. II. pp. 84, 86; Thos. Thomson, "An Outline of the Sciences . . ." London, 1830, Chap. XV. p. 564; "Encycl. Brit.," seventh edition, "Voltaic Electricity," p. 687; *Polytechnisches Centralblatt; Sc. Am. Supp.,* No. 404; Sturgeon's "Scientific Researches," Bury, 1850, p. 19; L. F. Kaemtz, *Phil Mag.,* Vol. LXII. p. 441; Poggendorff, Vol. II. pp. 873–875; Du Moncel, "Exposé . . ." Vol. III; Whewell's "Hist. of Ind. Sci.," Vol. II. p. 251; "Abhandl. d. Naturf. Gesellsch. zu Halle" for 1853–1856; Schweigger's *Journal für Chemie und Physik,* Vol. II. part iv. pp. 424–434; Vol. X for 1814 and Vol. XXXVIII for 1823; "Cat. Sc. Papers Roy. Soc.," Vol. V. pp. 589–592; "Bibl. Britan.," Vol. XVI, N.S., 1821, p. 197; Larousse, Vol. XIV. pp. 386–387. *Edinburgh Philosophical Journal,* July 1821, Vol. V. p. 113. For Seebeck, see *Phil. Mag.,* Vol. LXI, 1823, p. 146. For Poggendorff, see "Cat. Sc. Pap. Roy. Soc.," Vol. IV. pp. 952–956; Vol. VIII. pp. 638–640; "Bibl. Britan.," Vol. XVIII, N.S., 1821, p. 195; Pogg., "Annalen," Vol. CLX (biography).

In the editorship of Schweigger's *Journal,* which followed Gehlen's *Journal,* Mr. J. S. C. Schweigger was assisted, from 1828, by Franz W. Schweigger-Seidel, who was the author of "Lit d. Math. Natur.," published in 1828. (For the joint magnetic work of

J. S. C. Schweigger and Wilhelm Pfaff, see *Jour. f. Ch. u. Ph.*, Band X. heft i. for 1814.)

A.D. 1811.—Monsieur Dessaignes is first to establish a relation between electricity and phosphorescence, as is shown in the extract published in London from the Memoir which he had presented two years before to the French Institute. The general view he takes is that phosphorescence is produced by a particular fluid, which is set in motion by light, by heat, by electricity, as well as by friction, and that it is dissipated by overheating or by too long exposure to light.

It is asserted by Fahie (" Hist. of El. Tel.," pp. xiv, 297) that it was Dessaignes and not Seebeck who first discovered thermo-electricity. " Dessaignes," he says, " showed us how difference of temperature or heat could produce electricity." This was in 1815, or six years before Seebeck, who is always credited with the observation (Bostock's " History of Galvanism," London, 1818, p. 101). Many observations bearing on *thermo-electricity* had been made even long before Dessaignes. . . . In 1759 Æpinus called attention to the same phenomena, and pointed out that electricity of opposite kinds was developed at opposite ends of the crystal (tourmaline). In 1760 Canton observed the same properties in the topaz; and between 1789 and 1791 Haüy showed the thermo-electric properties of various other substances, as mesotype, prehnite, Iceland spar, and boracite.

References.—Priestley's " History of Electricity," 1767, pp. 314–326. For Dessaignes' other observations, see J. Farrar, " Elem. of Elec., Mag. and Electro-Mag.," 1826, p. 125, and *Phil. Mag.*, Vol. XLIV. p. 313. See also *Phil. Mag.*, Vol. XXXVIII. p. 3; *Journal des Mines*, Vol. XXVII. p. 213; Poggendorff, Vol. I. p. 563; " Cat. Sci. Pap. Roy. Soc.," Vol. II. pp. 272, 273; Chap. III. s. 3 of the " Electricity " article of the " Ency. Britannica."

A.D. 1811.—The idea of placing a lightning conductor through the body of a ship is first suggested by Mr. Benjamin Cook, of Birmingham, and is carried out by Mr. William Snow Harris, of Plymouth. Mr. William Sturgeon, who mentions the fact (" Lectures of Electricity," London, 1842, p. 208), adds that Mr. Harris " has formed the conductors into strips of copper, which are inserted in grooves in the after side of the masts from top to bottom and through the keelson to the sea. In one of the smaller men-of-war Mr. Harris carried his mizzen conductor through the powder magazine ! ! ! The evils attending these conductors arise principally from lateral explosions and electromagnetic influence."

References.—For Wm. Sturgeon, consult *Phil. Mag.*, Vol. XI, 1832, pp. 195, 270, 324; " Cat. Sc. Papers Roy. Soc.," Vol. V. pp. 876–878, Vol. VI. p. 758 and Vol. VIII. p. 1042.

A.D. 1811–1812.—Schübler (Gustav), Professor, of Tubingen, is the first to present a connected series of observations upon the electricity of the air, which were made at Stuttgart, during all kinds of weather and at regular daily intervals, between May 1811 and June 1812. Other observations previously carried on by Schübler, during 1805 and subsequent years, at Ellvanguen and Stuttgart are detailed at pp. 579, 580, Vol. VIII—and are also alluded to in article "Meteorology"—of the eighth "Britannica."

While De Lor was the first to observe, in 1752, the existence of electricity in the atmosphere, even when no lightning is visible, Schübler made the earliest known report upon the daily periodicity of the intensity of the electricity. The annual periodicity had been previously demonstrated by G. B. Beccaria, who published at Turin two able treatises on the subject during 1769 and 1775.

The origin of atmospheric electricity was, by Lavoisier, Laplace and Sir H. Davy, attributed in great part to the constant combustion taking place upon the earth's surface. Volta and Saussure believed it to arise from the process of evaporation, while Pouillet pointed out the influence of the processes of vegetation; Reich, however, showed that as neither developed electricity they could not produce it in the atmosphere. Peltier advanced the theory that mere evaporation without chemical action is not enough, and the experiments of Faraday and Armstrong showed that evaporation without friction is likewise insufficient. These theories are treated of in "Gaea-Natur und Leben," Köln and Leipzig, 1873, p. 322, and in Lardner's "Popular Lectures," 1859, Vol. II. pp. 149–160. The last named gives tables of many observations, and reports, among other matters, that the series of observations on the diurnal changes of atmospheric electricity which Schübler made, in 1811–1812, were repeated and confirmed at Paris in 1830 by M. Arago. During the month of March 1811 Schübler found that the mean time of the morning maximum was eight hours thirty minutes, and M. Arago ascertained the mean time for the same month to be eight hours forty-eight minutes.

References.—*Edin. Jour. of Sci.*, new series, Vol. III; *Biblio. Univers.*, Vol. XLII; *Annales de Ch. et de Ph.* for 1816, Vol. II. p. 85; "Jahrbuch der Ch. und Ph.," 1829; Gilbert's *Annalen*, Vols. XXXIX, XLIX, LI; Schweigger's *Journal*, Vols. II. p. 377; III. p. 133; VIII. pp. 21, 22, 25, 26, 28, 29; IX. pp. 348, 350, 351; XV. p. 130; XIX. pp. 1 and 11; XXV. p. 249; XXXI. p. 39; *Jour. de Phys.*, Vol. LXXV. p. 177; Vol. LXXXIII. p. 184; "Lehrbuch der Meteor," L. F. Kaemtz, Halle, 1832, Vol. I. p. 337; Vol. II. pp. 411, 414; "Annual of Sc. Disc." for 1862, pp. 99–103; L. Palmieri in *Lum. Elec.*, Paris, Oct. 31, 1891, pp. 209–212; "Sci. Pap. Roy. Soc.," Vol. V. pp. 559–562; Vol. VI. p. 755; "Bibl. Britan.," Vol. II, N.S. for 1816 pp. 93–113 (atmosph. electricity); Poggendorff, Vol. II. p. 853; Report on Atmospheric Electricity by F. J. F. Duprez, 1858, Part III. chap. ii. pp. 363–368;

Foggo, p. 124, Vol. IV of *Edin. Jour. Sci.*; J. J. Hemmer's observations at Mannheim from 1783 to 1787, Lehrbuch, etc., Vol. II. p. 418, and the recorded investigations of De Luc, Girtannier, Mayer, Monge, Pouillet, Becquerel, De Tressan, Arago, De Saussure, Delezenne, Helwig and Kaemtz.

A.D. 1811.—In the first volume of his "Cosmos" (London, 1849, Vol. I. pp. 240–241) Humboldt speaks of *islands of eruption*, or marine volcanoes, which can properly be classed among electrical phenomena, and alludes to the one observed on the 13th of June 1811 by Captain Tillard (Tilland), and to which he gave the name "Sabrina."

This volcano, which had previously appeared June 11, 1638 and December 31, 1719, off the island of St. Michael, in the Azores, is thus described in the *Philosophical Transactions*:

"Imagine," says Captain Tillard, "an immense body of smoke rising from the sea, the surface of which was marked by the silver rippling of the waves occasioned by the slight and steady breezes incidental to those climates in summer. In a quiescent state, it had the appearance of a circular cloud, revolving on the water like a horizontal wheel, in various and irregular involutions, expanding itself gradually on the lee side, when suddenly a column of the blackest cinders, ashes, and stones, would shoot up in the form of a spire, rapidly succeeded by others, each acquiring greater velocity and breaking into various branches resembling a group of pines; these again forming themselves into festoons of white feathery smoke. During these bursts, the most vivid flashes of lightning continually issued from the densest portion of the volcano, and the columns rolled off in large masses of fleecy clouds, gradually expanding themselves before the wind, in a direction nearly horizontal, and drawing up a quantity of water spouts, which formed a striking addition to the scene. In less than an hour, a peak was visible, and, in three hours from the time of our arrival, the volcano then being four hours old, a crater was formed twenty feet high, and from four to five hundred feet in diameter. The eruptions were attended by a noise like the firing of cannon and musketry mixed; as also with shocks of earthquakes sufficient to throw down a large part of the cliff on which we stood." (See description of the sudden appearance of the Island of St. Michael, etc., in Lectures by Dr. Webster, Professor of Chemistry and Mineralogy at Harvard College, Boston, 1822.)

A.D. 1811–1818.—Ure (Andrew), M.D., F.R.S., the first astronomer appointed to the Glasgow Observatory and the author of a Dictionary of Chemistry (the undisputed standard until the appearance of a similar work by Henry Watts), makes known the result

of his electrical experiments in the same line as those made by Aldini (A.D. 1793) upon the body of a recently executed criminal. Noad, who gives a greatly detailed account of the investigations, at pp. 338–341 of his " Manual," remarks that they " serve to convey a tolerably accurate idea of the wonderful physiological effects of the electrical agent, and will be impressive from their conveying the most terrific expressions of human passion and human agony."

Dr. Ure is the inventor of an improved eudiometer, for detonating or exploding gases by means of an electric shock or spark, which is fully described and illustrated in the " Electricity " article of the " Britannica."

References.—De la Rive, " Treatise on Electricity," Vol. II. pp. 489–490, also " Encycl. Metropol.," Vol. IV (Galv.), p. 197. Another report of Ure's experiments appears at pp. 634, 635 of the " Encycl. Brit.," article on " Voltaic Electricity," also in No. 12 of the *Journal Sci. and Arts*, and at p. 56, Vol. LIII of the *Philosophical Magazine*.

A.D. 1812.—Through the *New York Columbian*, of July 1812, Mr. Christopher Colles informs the public that the operation of his new telegraphs " will be shown from the top of the Custom House on Tuesdays, Thursdays and Saturdays from four to six o'clock in the afternoon."

In an explanatory pamphlet, he states that " eighty-four letters can be exhibited by this machine in five minutes, to the distance of one telegraphic station averaged at ten miles, and by the same proportion a distance of 2600 miles in fifteen minutes, twenty-eight seconds."

James D. Reid, who mentions this fact at p. 5 of his " Telegraph in America," says that the above was nothing but the already well-known European semaphore or visual signal, and that Colles worked his " machine " between New York and Sandy Hook for several years.

A.D. 1812.—On April 1 and 15, May 13 and June 17, Mr. M. Donovan, secretary of the Kirwanian Society of Dublin, reads before the latter body a long communication " On the Inadequacy of the Hypothesis at Present Received to Account for (explain) the Phenomena of Electricity," which was afterward ably criticized by J. A. de Luc, as will be seen by reference to the *Philosophical Magazine*, Vols. XLV. pp. 97, 200, 329–332, and XLVI. pp. 13, 14. In his treatment of Eeles' hypothesis (see A.D. 1755) Donovan gives some attention to the designed suppression by Priestley of Eeles' valuable papers from the *Philosophical Transactions*.

The above communication was followed by still more valuable

and much longer ones, read by Mr. Donovan before the same society, February 22, March 8, and March 22, 1815, entitled "On the Origin, Progress and Present State of Galvanism . . . and Inadequacy of the Hypotheses to Explain Its Phenomena . . ." a modified form of which obtained for its author the prize of the Irish Royal Society.

The sketch of the history of galvanism is divided into three periods. The first treats of the discoveries attaching to muscular contraction, and alludes to the observations of Sulzer, Galvani, Fabbroni, Humboldt, Pfaff, Fontana, Valli, Monro, Vassalli-Eandi, Fowler, Smuck, Marsigli, Grapengieser, Giulio, Rossi, Aldini and Wells. The second period reviews the gradual development of the physical and chemical power of combined galvanic arrangements, beginning with Nicholson and Carlisle, and refers to the many conclusions reached by Cruikshanks, Henry, Haldane, Ritter, Robertson, Brugnatelli, Fourcroy, Vauquelin, Thénard, Lehot, Trommsdorff, Simon, Helwige (Major Helvig), Twast, Bourguet, Erman, Grapengieser, Wollaston, Davy, Pfaff, Van Marum, Biot, Cuvier, Desormes, Bostock, Cuthbertson, Aldini, Lagrave, Jordan, Ritter and Wilkinson. The third period commences with the well-known generalizations of the chemical effects of galvanism made by Hisinger and Berzelius; their experiments on the invisible transfer of elements at a distance, and the explanation given by Grotthus of the invisible transfer of the elements of water. Following this, Donovan alludes to the announced decomposition of muriatic acid by W. Peel, Francis Pacchiani, and others, as well as the discovery of the source of mistakes in the Galvani Society investigations by Pfaff, Biot, Thénard and Davy; after which reference is made to the special observations of Sylvester, Grotthus, Wilson, Erman, Davy, Pontin, Gay-Lussac and Thénard, Children, De Luc, Singer, Murray and Maycock.

On the 5th of April 1815, Donovan reviewed the hypotheses of Volta and Fabbroni, as well as of the British philosophers Wollaston, Bostock and Davy, and, on the 19th of the same month, he read an additional paper on the inadequacy of the galvanic hypothesis, having previously (Dec. 28, 1814, and Jan. 11, 1815) presented to the Kirwanian Society a communication relative to a new theory of Galvanism.

References.—*Phil. Mag.*, Vols. XXXIX. p. 396; XLIV. pp. 334, 401; XLV. pp. 154, 222, 308, 381; XLVI. p. 401; XLVII. pp. 167, 204; also Vol. XXXVII. pp. 227, 245, on Mr. Davy's erroneous hypothesis of electro-chemical affinity, and Vols. XXII and XXIII of the *Trans. Royal Irish Academy* for Mr. Donovan's papers relating to improvements in the construction of galvanometers, on galvanometric deflections, etc. etc.

A.D. 1812.—Zamboni (Giuseppe), Italian physicist, Professor of Natural Philosophy in the Verona Lyceum, makes known through his "*Della pila elettrica a secco*" an improved method of constructing dry piles. He dispenses entirely with the zinc plates of De Luc and employs only discs of paper having one side tinned and the other coated with a thin layer of black oxide of manganese pulverized in a mixture of flour and milk ("Note historique sur les piles sèches," *Annales de Chimie et de Physique*, Vol. XI. p. 190).

His pile terminates in metallic plates, compressing the paper discs by means of silk ligatures, and the column is insulated by giving it a coating of either sulphur or shellac. In this apparatus the tinned surface is the positive element, the negative being the oxide of manganese, which replaces M. De Luc's Dütch gilt paper. In the later forms of Zamboni's pile the discs were formed of gilt and silvered paper pasted back to back. William Sturgeon remarks ("Scientific Researches," Bury, 1850, p. 200) that the Zamboni piles are those which have been the most securely protected against the action of the ambient air and which alone have maintained their original electrical intensity.

References.—Larousse, "Dict. Univ.," Vol. XV. p. 1452; K. F. Anton Von Schreibers in Gilbert's *Annalen*, LV; Placidus Heinrich (Schweigger's *Journal*, XV); Gustav Schübler, "Uber Zamboni's Trockne Säule," 1815–1816; G. F. Parrot (Gilbert's *Annalen*, LV); K. C. F. Jäger in Gilbert's *Annalen*, Vol. XLIX for 1815, pp. 47–66; De la Rive, "Treatise on Electricity," Vol. II. p. 852; A. M. Ampère, *Ann. de Chimie et de Phys.*, XXIX; John Farrar, "Elem. of Electricity," etc., 1826, p. 179; Zamboni and Ambrogio Fusinieri, *Ann. . . . Reg. Lomb., Veneto*, Vols. IV. pp. 128, 132; VI. pp. 31, 142, 143, 293; G. Resti-Ferrari, "Elettroscopio . . . del Zamboni"; *Ann. . . . Reg., Lomb., Ven.*, Vols. II. p. 229; III. p. 290; "Verona Poligrafo" for 1831, p. 87; *Mem. Soc. Ital.*, Vols. XXI, XXIII; *Mem. dell' Istit. Veneto*, Vol. II. pp. 239, 251; G. A. Majocchi, *Annali di Fisica*, Vol. VIII. p. 14; "Comm. dell' Ateneo di Brescia," 1832, p. 38; Sturgeon's "Researches," Bury, 1850, pp. 147, 199, etc., for observations of A. de la Rive and Francis Watkins; *Phil. Mag.*, Vol. XLV. pp. 67, 261; *Ann. Ch. et Phys.* for May 1816, Vol. II. pp. 76, etc., 82–87, and *Bibl. Britan.*, Vol. LVII. p. 225; also Vol. LVIII. p. 111 of the O.S., Vol. II, N.S. for 1816, p. 21 as well as Vol. XL. p. 190; "Bibl. Univ.," Bruxelles, 1831, Vol. XLVII. p. 183 (horloge électrique); "Edin. New Phil. Journal," 1829, Vol. XXI. p. 357. See likewise the references at Hachette (A.D. 1803), Dyckhoff (A.D. 1804), Maréchaux (A.D. 1806), De Luc (A.D. 1809); the illustration and description of M. Palmieri's dry pile in *Sci. Am. Supp.*, Nos. 512, 519, and the accounts of investigations made more particularly by MM. Beetz, Belgrado, Burstyn, Crosse, Du Bois Reymond, De la Rive, D'Arsonval Desruelles, Edelmann, Faraday, Gassiot, Gassner, Germain, Roul, Guérin, Haussman, Keiser, Schübler, Minotto, Pollak, Riess, Schmidt, Trouvé, Wagner, Watkins and Wolf.

A.D. 1812.—Schilling (Pawel Lwowitch), Baron (of Kannstadt), attaché to the Russian Embassy in Munich, and who had been two years before associated with S. T. Von Sömmering (Kuhn, p. 836), devises what he calls his "sub-aqueous galvanic conducting

cord "—a copper wire insulated with a thin coating of india-rubber and varnish. This was laid both underground and under the sea, and, it is asserted that, by means of an arrangement of charcoal points, he was enabled to explode powder mines across the Neva, near St. Petersburg, as well as also across the Seine, during the occupation of Paris by the allied armies.

References.—Hamel, " Bull. Acad. Petersb.," II and IV; also Wm. F. Cooke's reprint, 1859, pp. 20–22; Fahie's " History," p. 309.

From the moment Schilling first saw the telegraph of Sömmering (Aug. 13, 1810) he made many experiments (Prime's " Life of Morse," p. 277) with the view of introducing it into Russia and finally took a model of it to St. Petersburg during the year 1812 (" Sc. Am. Suppl.," No. 405). Hamel states (at p. 41 of Cooke's reprint) that one of his contrivances was exhibited to the Emperor Alexander as early as 1825. Of this, Dr. E. N. Dickerson, in his Henry Memorial Address before Princeton College, gives the date as 1824. Be that as it may, it was only after his return from China in 1832 (two years after Sömmering's death) that, following Ampère's suggestion as to the availment of Oersted's discovery, he submitted the apparatus which established for him the credit of having invented the electromagnetic telegraph.

Many authors have erroneously described Schilling's apparatus as consisting of a number of platinum wires insulated and bound together with a silken cord which put in motion thirty-six magnetic needles placed vertically in the centre of the multiplier by means of a species of key connecting with a galvanic pile. This account appeared at p. 43 of the " Journal des Travaux de l'Acad. de l'Industrie Française " for March 1839. The fact is that he employed but one magnetic needle and multiplier, with two leading wires, as proposed by Fechner, and was enabled by means of a combination of the deflections of the needle to the right and left to give all necessary signals for a complete correspondence by changing the poles of the battery at the ends of the wires. His call signal was given by a bell in connection with a clockwork, released by the deflection of a magnet.

References.—For a detailed explanation of the working of Schilling's telegraph, J. S. T. Gehler's " Physikalisches Wörterbuch " for 1838, Vol. IX. p. 111; Fahie's " History," pp. 310–313; " Sc. Am. Suppl.," No. 405, p. 6467.

From the account of the telegraphic collection at the 1873 Exposition, published by Dr. Edward Zetzsche in the " Austellungblatte " of the Vienna " Neue Freie Presse," the following is extracted: " Even after Prof. Oersted, of Copenhagen, had observed

the deviation of a magnetic needle under the influence of the current, neither the proposition of Ampère, at Paris, in 1820 (of employing thirty needles and sixty wires) nor that of Fechner, at Leipzig, in 1829 (twenty-four needles and forty-eight wires) gave any impulse to telegraphy. Only in 1832 did the Russian Councillor of State, Baron Schilling de Kannstadt (who had seen the telegraph of his friend Sömmering, and had made it known in Russia), invent a new instrument with but five wires, which number he subsequently reduced to one. In it, the movements of the needle were rendered more perceptible by means of little discs of paper attached to a silk thread, holding the needle in suspension. This telegraph, it is true, was not put in application on a large scale, for Schilling died in 1837, but, on the 23rd of Sept. 1835, he had already brought out his apparatus at Bonn and at Frankfort-on-the-Main, where it was seen amongst other persons by Prof. Muncke, who doubtless constructed a similar one which he took with him to Heidelberg."

It was only one year before his death that Schilling succeeded in obtaining the support of the Russian Government for his telegraph, and it was only after Muncke had shown it (March 6, 1836) to Wm. Fothergill Cooke, then a student in medicine at Heidelberg, that the latter produced his needle telegraph, which was followed by Cooke and Wheatstone's still more perfect instrument in 1837 (Prime's "Life of Morse," pp. 265, 276). Some improvements in Schilling's so-called deflective telegraph had, in the meantime, been made by Gauss and Weber at Göttingen, as well as by Steinheil at Munich.

Prior to his visiting Bonn (Meeting of Naturalists—Isis, Nog., 1836) Schilling had taken the working model of his telegraph to Vienna, where he made many experiments with it in conjunction with Baron Jacquin and with Prof. Andreas von Ettinghausen. Upon his return home from Germany in 1836, he declined invitations made him to bring his instruments to England (Dr. Hamel's St. Petersburg lecture on "The Telegraph and Baron Paul Schilling"), whilst, by direction of the Russian Commission of Inquiry, he set up an experimental telegraph in two chambers of the Palace of the Admiralty connecting the apparatus by a long line over ground and by a cable laid in the waters of the canal. The results proved so satisfactory that in May 1837 the Emperor Nicholas ordered a submarine line to be laid between St. Petersburg and Cronstadt. Schilling's death, on the 25th of July following, prevented, however, the execution of the project.

References.—Biography in *Sci. Am. Supp.*, No. 547, p. 8737; *Polytechnic Central Journal*, Nos. 31, 32 for 1838; *Lumière Electrique* for March 17, 1883; "Allg. Bauztg.," 1837, No. 52, p. 440; L. Turnbull,

Electro. Magn. Tel. p. 223; (Hibbard's Ev. 31; Channing, Ev. 41); Poggendorff, Vol. II. p. 798; *Annales Télégraphiques* for November to December 1861, p. 670; *Journal Soc. of Arts* for July 22, 1859, p. 598; References at Ronalds' "Catalogue," p. 457; Du Moncel, "Exposé," Vol. III. p. 8 and "Traité Théorique et Pratique du Tel. Elect.," Paris, 1864, p. 217; *Comptes Rendus*, Vol. VII for 1838, p. 82; *Journal Franklin Inst.* for 1851, p. 60; H. F. E. Lenz, "Uber die Praktische . . . Galvanismus," 1839; "Report of Smithsonian Inst.," 1898, pp. 224–225.

A.D. 1812–1813.—Morichini (Domenico Pini), eminent Italian physician, is the first to announce that unmagnetized steel needles can be rendered magnetic by making the focus of violet solar rays collected through a lens pass repeatedly from the middle to one end of the needle, without touching the other half (Zantedeschi, II. p. 214).

The long contention created by this announcement and the ingenious experiments of Mrs. Somerville, together with the results obtained by P. T. Riess and L. Moser, are detailed at p. 48 of Brewster's (1837) "Treatise on Magnetism." At p. 12 of his article (Vol. XIV of the eighth "Britannica"), Sir David Brewster states that Morichini's experiments were successfully repeated by both Dr. Carpi at Rome and the Marquis Ridolfi at Florence; but M. d'Hombre Firmas, at Alais, in France; Prof. Pietro Configliachi, of Pavia, and M. Berard, of Montpelier, failed in obtaining decided effects from the violet rays. In 1814 Morichini exhibited the actual experiment to Sir Humphry Davy, and in 1817 Dr. Carpi showed it to Prof. Playfair. A few months later Sir David Brewster met Davy at Geneva, and learned from him the fact that he had paid the most diligent attention to one of Morichini's experiments, and that he had actually seen with his own eyes an unmagnetized needle rendered magnetic by violet light. Then follow in the same article the account of Dr. Carpi's experiment as given to Brewster by Prof. Playfair, also details of the investigations of Mrs. Somerville, Mr. Christie, Sir William Snow Harris, Prof. Zantedeschi, of MM. Baumgartner and Barlocci, as well as those of Riess and Moser above alluded to.

References.—"Elogio storico del Cavaliere D. Morichini in *Mem. della Soc. Ital.*, Vol. XXVI. p. 3; Riess and Moser in *Phil. Mag. or Annals*, Vol. VIII. p. 155, 1830 and in Edin. *Trans.*, Vol. X. p. 123; "Library of Useful Knowledge" (El. Mag.), p. 97; *Zeitschrift*, Vol. I. p. 263; Noad, "Manual," pp. 532, 533; the article of Col. George Gibbs in Silliman's *Amer. Jour. of Sci.*, 1818, Vol. I. pp. 89, 90; *Annales de Chimie*, Vol. XLII. p. 304; Brewster's "Optics," p. 92; also articles "Optics," p. 596, "Light," p. 452 and "Electricity," p. 569 of the eighth "Britannica"; *Edin. Jour. of Sci.*, No. 4, p. 225; B. Gandolfi, "Antologia Romana," 1797; Harris, "Rud. Mag.," Parts I, II. p. 69; *Phil. Trans.* for 1826, pp. 132, 219; D. Olmstead, "Int. to Nat. Phil.," 1835, Vol. II. p. 194. See also Thomas Thomson's "Outline of the Sci.," p. 514, and Berzelius' "Traité de Chimie," Vol. I. p. 138 for Morichini's observations on galvanic energy; "Bibl. Brit.," Vol. LII, 1813, p. 21;

Vol. LIII, 1813, p. 195; Vol. LIV, 1813, p. 171 (Experiments of G. Babini in Florence); Vol. IV, N.S., 1817, pp. 1–8; Vol. V, N.S., 1817, p. 167; Vol. VI, N.S., 1817, p. 81; Vol. XI, N.S., 1819, p. 29 for the experiments of L. A. d'Hombre Firmas on Morichini's violet rays, whilst p. 174 of the same issue gives J. Murray's investigations as recorded in the "Phil. Mag." for April 1819.

Peter (Pietro) Configliachi, already named, was the successor of Volta as Professor of Natural Philosophy at the Pavia University, and became editor of the "Biblioteca Fisica d'Europa," the "Biblioteca Germanica," the "Biblioteca Italiana" and the "Giornale di Fisica, Chimica e Storia Naturale" (Larousse, "Dict. Univ.," Vol. IV. p. 908; J. J. Prechtl, in Schweigger's *Journal*, Vol. IV for 1812; Fr. Mochetti, "Lettera al P. Configliachi," Como, 1814; "Bibl. Britan.," Vol. LVIII, 1815, p. 305 and Vol. IV of the N.S. for 1817, pp. 1–8).

A.D. 1813.—Sharpe (John Robert), of Doe Hill, near Alfreton, transmits to the *Repertory of Arts* a letter, which appeared in its Vol. XXIX, second series, p. 23, wherein he alludes to p. 188, Vol. XXIV of the same series, containing an account of Sömmering's apparatus. He says:

"Without the slightest wish to throw a doubt over the originality of Mr. Sömmering's invention, I beg leave to mention that an experiment, showing the advantages to be obtained from the application of the certain and rapid motion of the electric principle through an extensive voltaic circuit to the purpose of the ordinary telegraph, was exhibited by me before the Right Hon. the Lords of the Admiralty, in the beginning of February 1813."

It is said that the Lords of the Admiralty spoke approvingly of it, but stated that as the war was over, and money scarce, they could not carry it into effect (*Saturday Review* for August 21, 1858, p. 190).

Ronalds says ("Catal.," p. 473):

"No description of this telegraph appears to have been printed. It was mentioned at the Admiralty after the invention and full description of Sömmering's, described fully and with figures in the Denkschriften of the Academy of Munich for 1809–1810, issued in 1811."

Mr. Benjamin Sharpe, nephew of J. R. Sharpe, is the author of "A Treatise on the Construction and Submersion of Deep-Sea Electric Telegraph Cables," London, 1861, wherein he alludes to the above, and asserts that his uncle "conveyed signals a distance of seven miles under water" (Fahie's "History," pp. 244–246; *Sci. Am. Supp.*, No. 404, pp. 6, 446).

A.D. 1813.—Deleuze (Joseph Philippe François), French physician, publishes his "Histoire Critique du Magnétisme Animal," containing the result of observations made by him during the previous twenty-five years upon animal magnetism.

According to Dr. Allen Thomson, of the University of Glasgow, Deleuze believed in the existence of an all-pervading magnetic fluid. This fluid, says he, is under the control of the will, and is constantly escaping from our bodies, forming around them an atmosphere, which, having no determinate current, does not act sensibly on the person near us; but, when urged and directed by our volition, it moves with all the force which we impress upon it; it is moved like the luminous rays emitted by substances in a state of combustion. The chief difference between the Deleuze and Puységur schools has reference to the various modes in which the magnetic fluid should be brought into action, and the suitable occasions for its employment.

During the year 1815 the Magnetic Society was established in Paris, with M. De Puységur as its president and M. Deleuze as vice-president, but it expired in 1820. In 1819 M. Deleuze had published his "Défense du Magnétisme Animal," in reply to the attack made upon the subject by M. Virey through the "Dictionnaire des Sciences Médicales," and he was followed, more particularly, by M. Bertrand, who issued in 1823 his "Traité du Somnambulisme," and in 1826 his still more important work, "Du Magnétisme Animal en France," etc. Respecting the last named Deleuze says:

"Of all the attacks directed against magnetism up to the present day, this is the most powerful, the most imposing, and the most ably combined. The author is a man of genius, etc. He has been occupied with magnetism for some years. He has joined its practice to that of medicine, and he has even taught its doctrines in public lectures. A more attentive examination and new experiments have dissuaded him from a belief which he himself propagated; he undertakes to undeceive others, and to prove that magnetism is a mere chimera. Certainly his conviction must be very strong."

References.—Article "Somnambulism," in the "Britannica," more especially for a review of, and extracts from, Deleuze's great work, also the translation of the latter by T. C. Hartshorn, of which the enlarged fourth edition was published at London in 1850, accompanied by notes and a life by Dr. Foissac.

A.D. 1813.—Brande (William Thomas), F.R.S., succeeds Sir Humphry Davy as Professor of Chemistry to the Royal Institution after having long been his assistant.

He was already favourably known through a long line of interest-

ing chemical experiments, one of which, treating of the effects of the galvanic current on albumen, had attracted very particular attention at the time it was communicated to the *Philosophical Transactions*. When he applied Davy's method to fluids containing albumen, the albumen and acid were found at the positive pole and the albumen and alkali at the negative pole, and he also observed that, although it remained fluid with a weak battery, a stronger one caused it to be separated in a coagulated form. In like experiments subsequently made by Golding Bird, coagulation took place in the positive vessel, while none occurred in the negative; after a time the contents of the former had an acid taste, and of the latter a caustic alkaline flavour. When all in the positive vessel was coagulated by the galvanic action, he found there hydrochloric acid mixed with chlorine and the alkali in the negative vessel.

He also repeated the experiments of Davy on the light developed by charcoal points connected with a powerful galvanic battery, and found that this light was as effectual as solar light in decomposing muriate of silver and other bodies, and in acting upon hydrogen and chlorine gases, causing them to detonate, but he could not produce the same effect by the moon's rays or by any other light.

The electricity developed in flame, which had received much attention from Paul Erman and others, was likewise investigated by Prof. Brande, whose conclusions are to be found detailed at Sec. III. chap. iii. part i. of the "Electricity" article in the "Encyclopædia Britannica." Therein is recalled the fact that A. L. Lavoisier, P. S. Laplace and Aless. Volta previously obtained clear indications of electricity by the combustion of charcoal, while H. B. de Saussure failed to develop electricity either by the combustion or explosion of gunpowder, and Humphry Davy could not obtain it through the combustion of charcoal or of iron in air or in pure oxygen. In the above-named article will also be found an account of the investigations of Pouillet and of Becquerel in the same line; some of the other well-known scientists who have treated more or less directly upon the subject being E. F. Dutour, J. S. Waitz, J. J. Hemmer, Heinrich Buff, G. Gurney, Carlo Matteucci, W. R. Grove, Michael Faraday, M. A. Bancalari, W. G. Hankel, F. Zantedeschi and M. Neyreneuf.

REFERENCES.—*Phil. Mag.*, Vol. XLIV. p. 124; *Phil. Mag. or Annals*, Vol. IX. p. 237; *Annales de Chimie*, 5e série, Vol. II; *Phil. Trans.* for 1809 and 1820; *Mémoires de Mathématiques*, Vol. II. p. 246; "Cat. Sc. Pap. Roy. Soc.," Vol. I. p. 48; "Bibl. Britan.," Vol. LVII, 1814, p. 11.

A.D. 1813.—Colonel Mark Beaufoy (already alluded to at Graham, A.D. 1722), describes in the first volume of Dr. Thomas

Thomson's *Annals of Philosophy* what has by many been called the most perfect form known of the variation compass. It is also to be found illustrated at p. 81, Vol. XIV of the eighth "Britannica," wherein it is said that he employed it in the valuable series of magnetic observations made by him between the years 1813 and 1821. It consists of a telescope, underneath the axis of which is a magnetic needle whose position is alterable in order to indicate the exact angle of deviation, or the declination of the needle from the true meridian.

Brewster states (eighth "Brit.," Vol. XIV. p. 54) that when the diurnal variation of the needle was first discovered it was supposed to have only two changes in its movements during the day. About 7 a.m. its north end began to deviate to the west, and about 2 p.m. it reached its maximum westerly deviation. It then returned to the eastward to its first position, and remained stationary till it again resumed its westerly course in the following morning. When magnetic observations became more accurate, it was found that the diurnal movement commences much earlier than 7 a.m., but its motion is to the east. At 7.30 a.m. it reaches its greatest easterly deviation, and then begins its movement to the west till 2 p.m. It then returns to the eastward till the evening, when it has again a slight westerly motion; and in the course of the night, or early in the morning, it reaches the point from which it set out twenty-four hours before. The most accurate observations made in England were those of Colonel Beaufoy, when the variation was about $24\frac{1}{2}'$ west. In these the absolute maxima were earlier than in Canton's observations, and the second maximum west about 11 p.m. Dr. Thomas Thomson alludes to the diurnal investigations of Barlow and Christie and others, and gives ("Outline of the Sciences," London, 1830, pp. 543–550) a table of the mean monthly variation of the compass from April 1817 to March 1819 as determined by Colonel Beaufoy. Mr. Peter Barlow, he says, has given in his "Essay on Magnetic Attractions" a very ingenious and plausible explanation of the daily variation by supposing the sun to possess a certain magnetic action on the needle.

REFERENCES.—*Phil. Mag.*, Vol. LIII, 1819, p. 387; LV, 1820, p. 394; W. S. Harris, "Rud. Mag.," Parts I, II, pp. 150–152; "Encycl. Metrop.," Vol. III (Magnetism), pp. 766, 767; *Annals of Phil.*, series 1, Vols. II, VI, IX, XVI, and N.S., Vol. I. p. 94, for Beaufoy's own summary of all his observations.

A.D. 1814.—Mr. Thomas Howldy addresses to the *Philosophical Magazine* a letter, dated Hereford, March 24, 1814, relative to "Experiments evincing the influence of atmospheric moisture on an electric column composed of 1000 discs of zinc and silver," wherein

he also makes reference to the dry pile of J. A. De Luc alluded to at A.D. 1809.

REFERENCES.—*Phil. Mag.*, Vol. XLIII. pp. 241, 363, and *Nicholson's Journal*, Vol. XXXV. p. 84; also the *Phil. Mag.*, Vol. XLI. p. 393, for a description of the electric column of 20,000 pairs of zinc and silver plates, and others, constructed during the previous year (1813) by Mr. George J. Singer.

The above-named letter was followed (*Phil. Mag.*, Vols. XLVI. pp. 401–408, and XLVII. p. 285) by a communication on the "Franklinian Theory of the Leyden Jar . . . with Some Remarks on Mr. Donovan's Experiments," and by another letter sent to MM. R. Taylor and R. Phillips (*Phil. Mag. or Annals*, Vol. I. p. 343) relative to the paper of William Sturgeon "On the Inflammation of Gunpowder by Electricity," which appeared at p. 20 of the last-named book.

An interchange of correspondence not long since through the columns of the London *Electrical Review*, for the purpose of ascertaining the period of the earliest use of carbon as a resistant, brought forth an extract from the "Treatise on Atmospheric Electricity," published at London and Edinburgh, 1830, by Mr. John Murray, of Glasgow, which reads as follows: "Mr. Howldy, of Hereford, an ingenious electrician, has by some novel experiments clearly proved the increased power of electricity if retarded in its progress; instead of using tubes of glass filled with water, as Mr. Woodward had done, he has employed a glass tube supplied with lamp black."

A.D. 1814.—Murray (John), Scotch physician and chemist, also Ph.D., and Professor of Chemistry and Materia Medica in the Edinburgh University, is the author of works entitled, "On Electrical Phenomena, and on the new substance called Jod (Iode)," also "On the Phenomena of Electricity," published at London, respectively, during the years 1814 and 1815 (Tilloch's *Phil. Mag.*, Vols. XLIII. pp. 270–272; XLV. pp. 38–41; "Catalogue Sci. Pap. Roy. Soc.," Vol. IV. pp. 556–557).

Dr. John Murray died July 22, 1820, in Edinburgh, the place of his birth, as will be seen by reference to Larousse, "Dict. Univ.," Vol. XI. p. 706, and to Poggendorff, Vol. II. pp. 243, 244. He should not be confounded, as has been done by many, with *Mr.* John Murray, whose papers, read before the Royal Society ("Catalogue Scientific Papers," Vol. IV. pp. 557–559; Vol. VI. p. 731), treat of the relations of caloric to magnetism, of the unequal distribution of caloric in voltaic action, etc., of aerolites, of the decomposition of metallic salts by the magnet, of the ignition of wires by the galvanic battery, of lightning rods, conductors, etc. (These

papers appear in Tilloch's *Phil. Mag.*, Vols. LIV, 1819, pp. 39–43; LVIII, 1821, pp. 380–382; LX, 1822, pp. 358–361; LXI, 1823, p. 207; LXII, 1823, p. 74; LXIII, 1824, pp. 130, 131; L. F. von Froriep, "Notizen . . ." for 1823, Vol. IV. col. 198; *Edin. Phil. Jour.*, Vols. XIV for 1826, pp. 57–62; XVIII for 1828, pp. 88–91; and in Sturgeon's *Annals*, Vols. III for 1838–1839, pp. 64–68; VII for 1841, pp. 82–83.)

Mr. John Murray is said to have been a lecturer on experimental philosophy, and one of his most interesting reviews is the one appearing at p. 62, Vol. XLIII of the *Phil. Mag.* regarding Ezekiel Walker's theory of combustion as deduced from galvanic phenomena. Murray thinks there is much obscurity in Mr. Walker's solution, which arises "from his using indiscriminately the terms heat (caloric) and combustion. Now caloric (the matter of heat) and combustion (the act of ignition) are not identical. What may be collected, however, from the general tenor of that paper is the theory of Lavoisier in a new dress."

At p. 17 of this same volume is a paper from Mr. John Webster on the agency of electricity in contributing the peculiar properties of bodies and producing combustion, while, at p. 20, is a letter from Mr. George J. Singer wherein he calls Mr. Walker a novice in the science of electricity, saying that among other things he "has yet to learn that a conducting body supported by dry glass and surrounded by dry air may be still very far from being insulated."

The treatise of Mr. John Murray on "Atmospheric Electricity" previously alluded to (at Thomas Howldy, A.D. 1814) was translated into French ("Mém. de l'Elec. Atm.") by J. R. D. Riffault, Paris, 1831.

REFERENCES.—*Phil. Mag.*, Vols. XLIII. p. 175; L. pp. 145, 312; LII. p. 60; LIII. pp. 268, 468; LVIII. p. 387; LX. p. 61; LXI. p. 394; LXII. p. 456; LXIII. p. 130; also pp. 306, 307 of Fahie's "History," regarding John Murray's "Notes to Assist the Memory in Various Sciences."

A.D. 1814.—Wedgwood (Ralph), member of the family whose name is inseparably connected with one of the most beautiful manufactures of pottery, completes an electric telegraph, upon which he has been steadily at work from 1806. Of its construction or mode of action he appears, however, to have left no particulars.

At pp. 178 and 180 of "The Wedgwoods . . ." by Llewellyn Jewett, London, 1865, appears the following:

"This Thomas Wedgwood was, I believe, cousin to Josiah, being son of Aaron Wedgwood, etc., etc. . . . He was a man of high scientific attainments, and has the reputation of being the first inventor of the electric telegraph (afterward so ably carried out by

his son Ralph) and of many other valuable works. . . . In 1806 Ralph Wedgwood established himself at Charing Cross, and soon afterward his whole attention began to be engrossed with his scheme of the electric telegraph, which in the then unsettled state of the kingdom—in the midst of war, it must be remembered—he considered would be of the utmost importance to the government. In 1814, having perfected his scheme, he submitted his proposals to Lord Castlereagh, and most anxiously waited the result . . . was informed that 'the war being at an end, the old system was sufficient for the country.' The plan, therefore, fell to the ground, until Prof. Wheatstone, in happier and more enlightened times, again brought up the subject with such eminent success. The plan thus brought forward by Ralph Wedgwood, in 1814, and of which, as I have stated, he received the first idea from his father, was described by him in a pamphlet, entitled 'An Address to the Public on the Advantages of a Proposed Introduction of the Stylographic Principle of Writing Into General Use; And Also an Improved Species of Telegraphy, Calculated for the Use of the Public, as Well as for the Government.'"

The pamphlet is dated May 29, 1815. Fahie gives ("History," pp. 125–127) extracts both from this pamphlet, regarding the electric Fulguri-Polygraph, and from the communication of Mr. W. R. Wedgwood to the *Commercial Magazine* for December 1846, urging his father's claims to a share in the discovery of the electric telegraph.

REFERENCES.—"Life of Wedgwood," by Miss Meteyard, 2 vols., 1865–1866; J. D. Reid, "The Telegraph in America," p. 70.

A.D. 1814.—Singer (George John), distinguished English scientist and writer, publishes the first edition of his valuable "Elements of Electricity and Electro-Chemistry," of which translations were made, in French by M. Thillaye, Paris, 1817, as well as in German and in Italian during the year 1819.

Mr. Singer is the inventor of the improvement upon Mr. Bennet's electroscope, which is to be found illustrated and described in nearly all works upon natural philosophy and the main design of which is to diminish, if not totally prevent, the amount of moisture generally precipitated upon the surface of insulators. Mr. Singer remarks that his arrangement so effectually precludes moisture that some of the "electrometers constructed in 1810 and which have never yet (1814) been warmed or wiped, have still apparently the same insulating power as at first." The use of this apparatus is strongly recommended by Dr. Faraday, whose instructions for the use of electrometers are given at great length at pp. 617–619, Vol. VIII of the eighth "Britannica."

After describing the above-named electrometer, Mr. William Sturgeon remarks ("Lectures," London, 1842, pp. 42, 43):

"It is frequently exceedingly difficult, without extensive reading, to confer the merit that is due to invention on the right party, and even then we sometimes err for want of proper information. Mr. Singer has hitherto, with most writers, had the exclusive merit of insulating the axial wire of the electroscope from the brass cap, by a glass tube; and it would appear from the description he gives of this improvement in his excellent treatise on electricity that he was not aware of anything of the kind being previously done. It appears, however, by an article of Mr. Erman in the *Journal de Physique*, Vol. LIX. p. 98, and *Nicholson's Journal*, Vol. X, published in 1805, that a Mr. Weiss had applied the glass tube for the purpose of insulating the axial wire of Bennet's electroscope. The account runs thus: 'The electrometer he (Mr. Erman) used was that distinguished in Germany as the electrometer of Weiss.' From this it would appear to have been long known. 'The length of its leaves of gold is half an inch, and the diameter of the glass cylinder which encloses them is three-quarters of an inch, the height being an inch and a half. Its cover of ivory does not project above the glass, and is perforated in the middle with a hole in which a *smaller glass tube is fixed, and through this last tube passes the metallic rod that serves to suspend the gold leaves.*' Singer's improvement, first published in 1814, would, therefore, consist in adding the brass ferrule, which covers the glass tube first introduced by Weiss."

Singer is also the inventor of one of the best-known amalgams for the cushions of the electric machine. It is described at p. 536, Vol. VIII of the eighth "Britannica," where it is said that a mixture of one part tin and two parts mercury is very effective, as is also the amalgam consisting of mosaic gold and the deutosulphuret of tin. (Other descriptions of the application of mosaic gold on the rubber are to be found at p. 432, Vol. II of "Young's Course of Lectures"; Woulfe, *Phil. Trans.*, 1771, p. 114; Bienvenu and Witry de Abt, *Lichtenb. Mag.*, Vols. II. p. 211, and IV. st. 3, pp. 58–61; Marquis de Bouillon, "Observ. de Physique," XXI.)

The dry electric columns which Mr. Singer invented are alluded to in *Phil. Mag.*, Vols. XLI. p. 393 and XLV. p. 359, while the results of his experiments on the electric fusion of metallic wires and the oxidation of metals, as well as those made upon the electricity of sifted powders and also in order to ascertain the effects of electricity upon gases, are to be found recorded at pp. 564, 592, 593 and 597, Vol. VIII of the 1855 "Britannica," and at p. 46 ("Electricity") of "Library of Useful Knowledge."

REFERENCES.—pp. 15, 16 of the last-named work; Poggendorff, Vol. II. pp. 938, 939; Figuier, "Exp. et Hist.," 1857, Vol. IV. p. 267; Sturgeon's "Lectures," 1842, p. 11; *Phil. Mag.*, Vols. XXXVII. p. 80; XLII. pp. 36, 261; XLIII. p. 20; XLVI. pp. 161, 259; likewise Ch. Samuel Weiss, at Poggendorff, Vol. II. pp. 1287–1289; "Bibl. Britan.," Vol. XLIII, 1810, p. 166; Vol. XLVII, 1811, pp. 3, 113, 213, 313; Vol. LVI, 1814, pp. 197, 318.

A.D. 1814–1815.—Fraunhofer—Frauenhofer (Joseph von), a practical Bavarian physicist and optician, who had been assistant to the celebrated George Reichenbach, publishes his observations on spectra in a pamphlet entitled "Bestimmung des Brechungs und Farbenzerstreuungs-Vermögens. . . ."

In the latter work will be found detailed his experiments with the electric spark, which he found to give a different spectrum from all other lights. Sir David Brewster says that in order to obtain a continuous line of electrical light Fraunhofer brought to within half an inch of each other two conductors, and united them by a very fine glass thread. One of the conductors was connected with an electrical machine and the other communicated with the ground. In this manner the light appeared to pass continuously along the fibre of glass, which consequently formed a fine and brilliant line of light. When this luminous line was expanded by refraction, Fraunhofer saw that, in relation to the lines of its spectrum, electric light was very different both from the light of the sun and from that of a lamp. In this spectrum he met with several lines partly very clear, and one of which, in the green space, seemed very brilliant compared with other parts of the spectrum (*Edin. Jour. of Sci.*, No. XV. p. 7). He saw in the orange another line not quite so bright, which appeared to be of the same colour as that in lamplight spectra; but in measuring its angle of refraction he found that its light was much more strongly refracted, and nearly as much as the yellow rays of lamplight. In the red rays toward the extremity of the spectrum, he observed a line of very little brightness, and yet its light had the same degree of refrangibility as the clear line of lamplight, while in the rest of the spectrum he saw the other four lines sufficiently bright. In a subsequent paper read at Munich in 1823 ("Neue Modifikation des Lichtes . . ." or "New Modification of Light") and in Schumacher's "Astronomische Abhandlungen," Fraunhofer states that, by means of the large electrical machine in the cabinet of the Academy of Munich, he obtained a spectrum of electric light in which he recognized a great number of light lines, and that he had determined the relative place of the lightest lines as well as the ratios of their intensities.

The introduction of the electric spark for the purpose of volatilizing metals was an important step in the development of spectral

analysis, but although used by both Wollaston and Fraunhofer its true value in that particular line was not realized for many years after their time.

Fraunhofer is not only celebrated as one of the founders of spectrum analysis, but he is well known also as the inventor of many important philosophical instruments, being the constructor of the great Dorpat parallactic telescope, called by Struve *the giant refractor.* It was during the year 1814 that he measured and described the innumerable dark lines of the solar spectrum known as Fraunhofer's lines, which were first noticed by Wollaston and reported upon by the latter to the Royal Society in 1802.

References.—M. Merz, "Das Leben und Wirken Fraunhofers," Landshut, 1865; Ninth "Encycl. Brit.," Vol. IX. p. 727; "Abh. der K. Bayer, Akad. d. Wiss." for 1814 and 1815; Fraunhofer's biography in the "Memoirs of the Astronomical Society of London," Vol. III. p. 117; his "Determination . . ." München, 1819; Whewell, "Hist. of Ind. Sci.," 1859, Vol. II. p. 475; *Sci. Am.*, Nov. 19, 1887, p. 321; *Phil. Trans.* for 1814, pp. 204, 205, and for 1820, p. 95; Tyndall, "Heat as a Mode of Motion," 1873, pp. 485, 486; article "Optics" in eighth "Encycl. Brit.," Vol. XVI. pp. 544, 588, 591; Sir David Brewster's article on "Electricity" in the "Encycl. Brit."; "Mem. of the Roy. Bav. Acad. of Sci." for 1822; "On the Spectrum of the Electric Arc," in Jas. Dredge's "Elec. Illum.," Vol. I. pp. 32, 36; *Edin. Trans.*, Vol. VIII for 1822; *Edin. Jour. Sci.*, Vol. XIII. pp. 101, 251; *Biblioth. Univ.*, Vol. VI. p. 21, as per Becquerel's "Traité . . ." Vol. I. p. 23; Dr. William A. Miller's first and third lectures before the Royal Institution in 1867; Houzeau et Lancaster, "Bibl. Gén.," Vol. II. p. 136; Rich. A. Proctor, "Old and New Astronomy," 1892, p. 787.

A.D. 1815.—Bohnenberger (Johann Joseph Friedrich von), 1765–1831, Professor of Mathematics and of Astronomy at the Tübingen University, constructs an extremely sensitive electrometer by suspending a single strip of gold leaf upon a wire midway between, though apart from, the insulated terminating discs of De Luc's column.

With this contrivance he found that, however slightly the leaf was electrified, it was drawn to one of the poles according to the nature of the electricity affecting it, and he was thus enabled to observe not only the presence of the slightest electrical influence, but the kind of electricity which was present.

Noad gives, at p. 30 of his "Manual," an illustration of the electrometer as subsequently improved by Becquerel, and states that Mr. Sturgeon describes ("Lectures on Galvanism," 1843) a somewhat similar arrangement, the delicacy of which he states to be such that the cap (plate) being of zinc and of the size of a sixpence, the pendant leaf is caused to lean toward the negative pole by merely pressing a plate of copper, also the size of a sixpence, upon it, and when the copper is suddenly lifted up the leaf strikes. The different electrical states of the inside and outside of various

articles of clothing were readily ascertained by this delicate electroscope.

M. Gottlieb Christian Bohnenberger, of Neuenberg (1732–1807), is the author of several works treating particularly of the electrical machine, the electric spark, the electric doubler, etc., published at Stuttgart between 1784 and 1798.

REFERENCES.—"La Grande Encyclopédie," Vol. VII. p. 84; L. W. Gilbert, *Annalen der Physik*, Vols. XXIII (for Behrend's); XLIX, LI (for "Beschreibung . . . empfindlichen elektrometers . . ."); *Annales de Chimie et de Physique*, Vol. XVI. p. 91; J. C. Poggendorff, "Biogr.-Liter. Handwörterbuch . . ." Vol. I. p. 226; *Sci. Am. Supp.*, No. 519, p. 8290, for Pouillet's remarks upon the effectiveness of dry pile electroscopes; De la Rive, "Treatise on Electricity," Vol. I. pp. 54–56.

A.D. 1815.—Mr. B. M. Forster sends to the *Philosophical Magazine* (Vol. XLVII. pp. 344–345) the description of an electrical instrument called "The Thunderstorm Alarum," which can be made to show the effect produced by the passage of a charged cloud over an *atmospherical electrometer*.

He had several years before described, at p. 205 of the same publication, a method of fitting up in portable form one of De Luc's electrical columns, respecting which latter he subsequently addressed communications, which appeared in Vols. XXXV. pp. 317, 399, 468; XXXVI. pp. 74, 317, 472; XXXVII. pp. 197, 265, also relative to one which he constructed and which ran continuously for five months.

REFERENCES.—*Phil. Mag.*, Vol. IV for 1828, p. 463; eighth "Britannica," Vol. XXI. p. 619.

A.D. 1815.—Gregory (Olinthus Gilbert), LL.D., Professor of Mathematics at the Royal Military Academy, Woolwich, in his "Treatise on Mechanics," London, 1815 (Vol. II. pp. 442–449), describes the methods of transmitting distant signals introduced by Polybius, the Marquis of Worcester, Robert Hooke, Amontons and Chappe, and alludes to an improved telegraph described in the "Gentleman's Magazine," as well as to the so-called nocturnal telegraph, of which an account is to be found in the *Repertory of the Arts and Manufactures* ("Biographie Générale," Tome XXI. p. 903).

A.D. 1815.—In the *Philosophical Magazine* (Vol. XLVI. pp. 161, 259), will be found an account of the electrical experiments of M. De Nelis, of Mechlin, or Malines, in the Netherlands, with an extension of them by George J. Singer and Andrew Crosse.

These allude to many investigations made during previous years by M. De Nelis, who reported upon them to Mr. Tilloch and to

M. de la Méthérie, and which show "very remarkable and permanent evidence of the expansive power of the electric charge." Singer adds: "It is difficult to contemplate such extraordinary mechanical effects without admitting that the power by which they are produced has at least the leading characteristics of a material substance." At p. 127, Vol. XLVIII of the *Phil. Mag.*, is an account of some further electrical experiments of M. De Nelis, one of which is intended to improve the simple current with an apparatus not insulated by discs. In this communication, which bears date July 10, 1815, he discourses upon the theory of the two fluids.

A.D. 1816.—Coxe (John Redman), M.D., Professor of Chemistry in the University of Pennsylvania, is the second to propose a system of transmitting signals, based, like Sömmering's (A.D. 1809), upon the discovery of Nicholson and Carlisle.

In the first series of Dr. Thos. Thomson's *Annals of Philosophy* for 1816 (not 1810), Vol. VII. pp. 162, 163, will be found Coxe's letter "On the Use of Galvanism as a Telegraph," wherein he says:

"I have contemplated this important agent as a probable means of establishing telegraphic communication with as much rapidity, and perhaps less expense, than any hitherto employed. I do not know how far experiment has determined galvanic action to be communicated by means of wires; but there is no reason to suppose it confined as to limits, certainly not as to time. Now, by means of apparatus fixed at certain distances, as telegraphic stations, by tubes for the decomposition of water, metallic salts, etc., regularly arranged, such a key might be adopted as would be requisite to communicate words, sentences or figures, from one station to another, and so on to the end of the line. . . . As it takes up little room, and may be fixed in private, it might in many cases of besieged towns, etc., convey useful intelligence with scarcely a chance of detection by the enemy. However fanciful in speculation, I have no doubt that, sooner or later, it will be rendered in useful practice. I have thus, my dear sir, ventured to encroach on your time with some crude ideas that may serve perhaps to elicit some useful experiments in the hands of others. When we consider what wonderful results have arisen from the first trifling experiments of the junction of a small piece of silver and zinc in so short a period, what may not be expected from the further extension of galvanic electricity? I have no doubt of its being the chief agent in the hands of nature in the mighty changes that occur around us. If metals are compound bodies, which I doubt not, will not this active

principle combine their constituents in numerous places so as to explain their metallic formation; and if such constituents are in themselves aeriform, may not galvanism reasonably tend to explain the existence of metals in situations in which their specific gravities certainly do not entitle us to look for them?"

Coxe does not appear, however, to have at any time made satisfactory experiments, and his systems were considered impracticable until worked out by Alex. Bain during the year 1840.

At pp. 99–110, Vol. II of Dr. Coxe's *Emporium of Arts and Sciences*, Philadelphia, 1812, will be found his illustrated "Description of a Revolving Telegraph," for conveying intelligence by figures, letters, words or sentences, upon which plan, he says, he constructed a small telegraph that worked "readily and appropriately, although by no means fitted with the various pulleys, etc., to facilitate the motion of the ropes."

References.—For full explanation of Coxe's systems, see L. Turnbull, "Elect. Mag. Tel." Highton's "Electric Telegraph," p. 39; *Jour. Franklin Inst.*, Vol. XXI. for 1851, pp. 332, 333; *Comptes Rendus* for 1838, Vol. VII. pp. 593, etc.; *Sci. Am. Supp.*, Nos. 404, p. 6446, and 453, p. 7234; Alfred Vail, "The American Electro-Magnetic Telegraph," pp. 128, 129; Prime's "Life of Morse," p. 263.

A.D. 1816.—In Part I of the *Philosophical Transactions* for 1816, and at p. 14, Vol. XLVII of the *Philosophical Magazine*, will be seen an account of the observations and experiments made by Mr. John T. Todd on the *torpedo* off the Cape of Good Hope, during the year 1812 ("Abstracts of Papers . . . Roy. Soc.," Vol. II. p. 57).

It is said that the *torpedo* in this locality is never more than eight nor less than five inches in length, and never more than five nor less than three and a half inches in breadth. Mr. Todd found the columns of their electrical organs to be larger and less numerous in proportion than those described by Hunter, and that they appeared to be of a cylindrical form, while from a number of experiments he drew, among other conclusions, the fact that a more intimate relation exists between the nervous system and electrical organs of the *torpedo*, both as to structure and functions, than between the same and whatsoever organs of any known animal. (See Hunter at A.D. 1773.)

Reports of another series of experiments, carried on by Mr. Todd at La Rochelle during 1816, will be found in the *Phil. Trans.* for the year following as well as at p. 57, Vol. II of the "Abstracts of Papers . . . of the *Phil. Trans.*, 1800–1830." The last-named investigations were made especially to determine whether the *torpedo* possessed any voluntary power over the electrical organs,

either in exciting or interrupting their action, except through the nerves of these organs.

A.D. 1816.—Philip—Phillip—(Wilson), English physician, publishes in the *Philosophical Transactions* a continuation of researches made by him to establish the relations existing between the phenomena of life and voltaic electricity. Noad gives (" Manual," pp. 341–344) an account of some of the experiments made on animals to prove the analogy existing between the galvanic energy and the nervous influence, and he alludes also to the fact of asthma having been relieved by galvanism through Dr. Philip, whose treatment had received the endorsement of Dr. Clarke Abel, of Brighton.

REFERENCES.—*Journal of Science,* Vol. IX. See also Faraday's " Experimental Researches," 1791 and note; " Abstract of Papers . . . *Phil. Trans.*, 1800–1830," Vol. II for 1822, p. 156.

A.D. 1816.—The Rev. James Bremmer, of the Shetland Islands, is rewarded by the Society of Arts for his night telegraph, the operation of which consists in the alternate exhibition and concealment of a torch in manner similar to that devised by Joachimus Fortius for Bishop Wilkins, as stated at A.D. 1641. This plan is said to have been successfully operated between the Copeland Island lighthouse and Port Patrick on the other side of the English Channel.

Particulars of the above-named night telegraph, as well as of the apparatus devised for day service, will be found in the *Trans. of the Soc. of Arts,* Vol. XXXIV. pp. 30, 213–227. The day telegraph consisted of a framework, having two circular openings, in each of which was a semicircular screen or shutter which, revolving upon an axis in the centre of the circle, was capable of assuming four different positions. This contrivance expressed an alphabet of sixteen letters, by dividing the latter into four classes of four each, and making one screen or shutter express the class, while the other indicated the number of the letter in that class.

A.D. 1816.—Sir Home Riggs Popham (1762–1820) British naval officer, who had been a rear-admiral in 1814, introduces his land semaphore which shows a great improvement upon all previous ones and at once replaces the Murray apparatus heretofore used by the English Admiralty (see A.D. 1795). It consists only of two arms placed upon the same hollow hexagonal mast, and movable upon separate pivots, each of which can be made to assume six different positions, giving together forty-eight different signals. It is fully described and illustrated at pp. 30, 167–177, Vol. XXXIV of the *Trans. of the Soc. of Arts,* and also appears in the " Telegraph " article, Vol. II of the " Encycl. of Useful Arts," as well

as at p. 149, Vol. XXIV of the "Penny Encycl.," at pp. 67, 68, Vol. VIII of the ("Arts and Sciences") "English Encycl.," and in the "Telegraph" article by Sir John Barrow, one of the secretaries to the Admiralty, in the seventh "Britannica."

In this same year (1816), Sir Home Popham also introduced a ship semaphore, which latter, as well as other similar devices of his construction, is to be found in the several publications already mentioned (the "Navy" article of the "Britannica" and pp. xii, xiii of Ronalds' "Catalogue").

A.D. 1816.—Ronalds (Francis), English experimentalist (1788–1873)—F.R.S., 1844, knighted 1870—whose serious attention to the development of electrical science appears to date from his meeting with M. De Luc in 1814, constructs at Hammersmith his telegraph which is the type of all dial instruments and which first presents the employment of two synchronous movements at the two stations. The telegraph is fully described and illustrated in the "Description of an Electrical Telegraph and of Some Other Electrical Apparatus," 8vo, 83 pages, which Mr. Ronalds issued in pamphlet form, London, 1823, and which is said to be the first work published on electric telegraphy. Copious extracts from this are to be found at pp. viii–xi of the Ronalds "Catalogue," and at pp. 129, 135–145, of Fahie's "History," the latter also containing several fine plates reproduced from the original work.

For his experimental line, Ronalds "erected two strong frames of wood at a distance of 20 yards from each other, and each containing 19 horizontal bars; to each bar he attached 37 hooks, and to the hooks were applied as many silken cords, which supported a small iron wire (by these means well insulated), which (making its inflections at the points of support) composed in one continuous length a distance of rather more than eight miles." After making many experiments with this overhead line, he thus laid one underground:

"A trench was dug in the garden 525 feet in length, and four feet deep. In this was laid a trough of wood two inches square, well lined on the inside and out with pitch, and within this trough thick glass tubes were placed, through which the wire ran."

His biographer, Mr. Frost, adds:

"In order to prevent the tubes from breaking by the variation of temperature, each length was laid a short distance from the next length, and the joint made with soft wax. The trough was then covered with pieces of wood, screwed upon it whilst the pitch was hot. They were also well covered with pitch, and the earth then thrown into the trench again."

Mr. Edward Highton, at p. 40 of his work, the "Electric Telegraph," 1852, says:

"Ronalds employed an ordinary electric machine and the pith-ball electrometer in the following manner. He placed two clocks at two stations; these two clocks had upon the second hand arbor a dial with twenty letters on it; a screen was placed in front of each of these dials, and an orifice was cut in each screen, so that only one letter at a time could be seen on the revolving dial. The clocks were made to go isochronously; and as the dials moved round the same letter always appeared through the orifices of each of these screens. The pith-ball electrometers were hung in front of the dials. The attention of the observer was called through the agency of an inflammable air gun fired by an electric spark."

Realizing the value of his invention, Ronalds strove to bring it before the English Government, but was met (Aug. 5, 1816), with much the same encouragement we have seen vouchsafed Sharpe (A.D. 1813), and Wedgwood (A.D. 1814), viz. "Telegraphs of any kind are now wholly unnecessary and no other than the one now in use will be adopted." The one alluded to was the semaphore line between London and Portsmouth, originally of the Chappe pattern and improved upon by Charles W. Pasley and Rear Admiral Popham.

Alluding to Mr. (afterward Sir) John Barrow's letter in a note at p. 24 of his work Ronalds says:

". . . Should they again become necessary, however, perhaps electricity and electricians may be indulged by his Lordship and Mr. Barrow with an opportunity of proving what they are capable of in this way."

He was so disappointed that he not long after announced his "taking leave of a science which once afforded him a favourite source of amusement," and that he was "compelled to bid a cordial adieu to electricity." Fortunately for the scientific world, however, he afterward gave his attention again to electrical matters as is evidenced by many important papers contained in the publications noted below.

In Ronalds' aforenamed work the phenomenon of retardation of signals in buried wires is clearly foreseen and described, although Zetzsche endeavours to combat this assertion at p. 38 of his "Geschichte der Elektrischen Telegraphie," Berlin, 1867. Speaking of the apprehended difficulty of keeping the wire charged with electricity, Ronalds suggests that when not at work "the machine be still kept in gentle motion to supply the loss of electricity by default of insulation; which default, perhaps, could not be avoided, because (be the atmosphere ever so dry, and the glass insulators

ever so perfect), conductors are, I believe, robbed of their electricity by the same three processes by which Sir Humphry Davy and Mr. Leslie say that bodies are robbed of their sensible heat, *viz.* by radiation, by conduction, and by the motion of the particles of air." He also gives descriptions of an improved electrical machine (eighth "Britannica," Vol. VIII. p. 536; *Sci. Am. Supp.*, No. 647, p. 10326; Noad's "Manual," p. 69), of a new method of electrical insulation and of some experiments on Vesuvius (*Quarterly Jour. of Sci.*, Vols. II. p. 249; XIV. pp. 332–334), of a new electrograph for registering the charge of atmospheric electricity, of a pendulum doubler (*Edin. Phil. Jour.*, Vol. IX, 1823, pp. 323–325) and of an attempt to apply M. De Luc's electric column to the measurement of time. His other contributions relative to the dry pile are to be found in the *Phil. Mag.*, Vols. XLIII. p. 414, and XLV. p. 466.

References.—"Biog. Mem. of Sir Francis Ronalds, F.R.S.," by Alfred J. Frost, in Ronalds' "Catalogue"; "Mem. of Dist. Men of Science," by William Walker; Ronalds' "Corres. and Memoir.," in 1848–1849, to 1853, to April 17, 1855, to June 5, 1856, to Sept. 2, 1862, and in 1866–1870; Ronalds' "Walk Through . . . Exh. of 1855"; *Illustrated London News* of April 30, 1870; eighth "Britannica," Vol. VIII. pp. 622, 627, for Ronalds' improved electrometers and his telegraph; *Nature*, London, Nov. 23, 1871, Vol. V. p. 59; *Journal of the Telegraph*, March 15, 1875, Vol. VIII. p. 82, reporting the inaugural address of Mr. Latimer Clark before the English Society of Tel. Engineers; *Comptes Rendus* for 1838, Vol. VII. pp. 593, etc.; *Sci. Am. Supp.*, No. 384, pp. 6, 127; No. 547, p. 8735, and No. 659, p. 10521, for his Telegraph; "Bombay Mag. Observatory," 1850; *Fortschrift des Phys.*, Vol. III. p. 586, and Buys-Ballot "Meteor. Preisfrage," 1847, for Ronalds' apparatus to measure atmospheric electricity; *Phil. Mag.*, Vols. XLIV. p. 442; XLV. p. 261; XLVI. p. 203; and third series, Vols. XXVIII for 1846; XXXI. p. 191; British Ass. Reports for 1845, 1846, and Reports concerning the Kew Observatory for 1845, 1850, 1852; *Phil. Trans.* for 1847, Moigno's *Le Cosmos*, Vol. XIII; L. Von Forster, "All Bauzeitung" for 1848, p. 238; Noad's "Manual," pp. 184, 185, 748; Knight's "Mechanical Dictionary," Vol. I. p. 708; Turnbull's "Electromagnetic Telegraph," p. 22; *Annals of Electricity*, Vol. III. p. 449; "English Cyclop." (Arts and Sci.), Vol. VIII. pp. 71, 72; *Jour. Soc. Teleg. Eng.*, 1879, Part XV, xxxviii; Vol. VIII, first part, p. 361; Reply to Mr. W. F. Cooke's pamphlet, "The Elec. Teleg.: Was it Invented by Prof. Wheatstone?" London, 1855; Du Moncel, Vol. III; "Telegraphic Tales," 1880, p. 42; J. D. Reid, "The Telegraph in America," 1887, p. 71; Ure's "Dict. of Arts," etc., London, 1878, Vol. II (Elect. Metal.), p. 230; T. P. Schaffner, "Tel. Man.," 1859, pp. 147–156; Silliman, "Principles of Physics," 1869, p. 617; "Edin. Phil. Journal," 1823, Vol. IX. pp. 322, 395.

A.D. 1816.—Porret (Robert) (1783–1868) communicates to the *Annals of Philosophy* (Vol. VIII. p. 74) a paper "On Two Curious Galvanic Experiments" (Electrovection, Voltaic Endosmose, or Electro-chemical Filtration).

He observed that when water was placed in a diaphragm ap-

paratus, one side of which was connected with the positive and the other side with the negative electrode of the battery, that a considerable portion of the liquid was transferred from the positive toward the negative side of the arrangement. It has since been found that the same result occurs in a minor degree when saline solutions are electrolyzed, and, generally, the greater the resistance which the liquid offers to electrolysis the greater is the amount which is thus mechanically carried over. . . . It appears from the researches of Wiedemann (Pogg., *Ann.*, Vol. LXXXVII. p. 321), which have been confirmed by those of Quincke, that the amount of liquid transferred, *cæteris paribus*, is proportioned to the strength or intensity of the current; that it is independent of the thickness of the diaphragm by which the two portions of liquid are separated; and that when different solutions are employed, the amount transferred in each case, by currents of equal intensity, is directly proportional to the specific resistance of the liquid. Miller, from whom the above is taken, says that this transfer has been minutely studied by Quincke, and gives an account of the latter's work extracted from the *Ann. de Chimie*, LXIII. p. 479. Brewster's allusion to Porret and Wiedemann (eighth "Britannica," Vol. VIII. p. 630) is followed by the statement that Mr. Graham considers ordinary endosmose as produced by the electricity of chemical action.

References.—Graham, Vol. II. p. 266; De la Rive's "Electricity," Chap. IV. pp. 424–443; "Roy. Soc. Cat. of Sci. Papers," Vol. IV. pp. 987, 988; Wm. Henry, "Elem. of Exp. Chem." 1823, Vol. I. p. 178; C. Matteucci, "Traité des Phénom. Elect. Phys.," 1844, p. 262 for Porret and Becquerel; Sturgeon's "Sc. Researches," Bury, 1850, p. 544; Poggendorff, Vol. II. p. 503; "Bibl. Britan.," Vol. III, N.S., 1816, p. 15 (Thomson's "Annals" for July 1816).

A.D. 1817.—Mr. J. Connolly makes known through an English and French pamphlet, entitled "An Essay on Universal Telegraphic Communication," the details of his portable telegraph.

As shown in the thirty-sixth volume of the *Transactions of the Society of Arts* and in the twenty-fourth volume of the "Penny Cyclopædia," his apparatus consists merely of three square boards painted with simple devices, like triangles, crescents, etc., the colours on the one side being the reverse of those on the other. Each of the six figures thus obtained is capable of producing four different distinct signals, making in all twenty-four, by successively turning each side of the board downward. In experiments made at Chatham, boards only eighteen inches square were found to answer for a distance of two miles, with a telescope having a magnifying power of twenty-five; and Mr. Connolly had also, it is said, exhibited these signals between Gros-nez and Sarque, a distance of seventeen miles, with boards twelve feet square.

At pp. 205, 208, of the *Transactions of the Society of Arts*, 1818, Vol. XXXV, and at p. 98, Vol. XXXVI for 1819, will be found Mr. Connolly's system of telegraphing by means of flags in manner different from that of Lieut.-Col. John Macdonald alluded to at Pasley, A.D. 1808.

A.D. 1817.—In the "Encycl. Brit." article treating of the influence of magnetism on chemical action, it is said that M. Muschman, Professor of Chemistry in the University of Christiania, made experiments to ascertain the effect of the earth's magnetism on the precipitation of silver.

Desirous of explaining the chemical theory of the tree of Diana (*Arbor Dianæ*, first observed by Leméry), "he took a tube like a siphon and poured mercury into it, which accordingly occupied the lower part of the two branches; above the mercury he poured a strong solution of nitrate of silver. He then placed the two branches of the siphon so that the plane passing through them was in the magnetic meridian, and after standing a few seconds the silver began to precipitate itself with its natural lustre; but it accumulated particularly in the northern branch of the siphon, while that which was less copiously precipitated in the other branch had a less brilliant lustre, and was mixed with the mercurial salt deposited from the solution." Muschman and Prof. Hansteen, having repeated this experiment with the same result, concluded that the magnetism of the earth had an influence on the precipitation of silver from a solution of its nitrate, and Muschman inferred from the experiment the identity of galvanism and magnetism (eighth "Britannica," Vol. XIV. p. 42).

A.D. 1817.—Freycinet (Claude Louis Desaulses de) (1779–1842), captain in the French navy, is sent in command of an expedition fitted out by the French Government for the purpose of making scientific observations in a voyage round the world. The experimental stations were the Island of Rawak (near the coast of Guinea), Guam (one of the Ladrones), the Isle of France, Mowi (one of the Sandwich Islands), Rio Janeiro, Port Jackson, Cape of Good Hope, Paris and the Falkland Islands, as described in his "Voyage Autour du Monde . . ." Paris, 1842.

His observations on the diurnal variations of the needle, which confirm the investigations made by Lieut.-Col. John Macdonald (A.D. 1808), are to be found at p. 54, Vol. XIV of the eighth "Britannica."

REFERENCES.—His "Voyage de Découvertes . . . 1800–1804 . . ." (F. Péron and Louis Freycinet), also his "Navigation et Géog. . . ."

1815; the note at p. 158, Vol. I of Humboldt's "Cosmos," London, 1849; *Phil. Mag.*, Vol. LVII. p. 20.

A.D. 1817.—In Vol. XLII. pp. 165, 166, of the *Transactions of the Society of Arts* will be found a record of the explanation of his magnetic guard for needle pointers which Mr. Westcott made before the Committee of Mechanics during the year 1817. This is said to consist of several "bar magnets smeared over with oil placed in a frame behind the grindstone."

A.D. 1818.—Bostock (John) (1774–1846), English physician, F.R.S., lecturer at Guy's Hospital, publishes in London his "Account of the History and Present State of Galvanism," which is scarcely more than a compilation of works treating of that branch of science.

One of the passages is, however, worth quoting, for it reflects the opinion shared by many physicists of the time that the resources of the galvanic field were already wellnigh exhausted. It thus appears at p. 102: "Although it may be somewhat hazardous to form predictions respecting the progress of science, I may remark that the impulse which was given in the first instance by Galvani's original experiments, was revived by Volta's discovery of the pile, and was carried to the highest pitch by Sir H. Davy's application of it to chemical decomposition, seems to have, in a great measure, subsided. It may be conjectured that we have carried the power of the instrument to the utmost extent of which it admits; and it does not appear that we are at present in the way of making any important additions to our knowledge of its effects, or of obtaining any new light upon the theory of its action."

Bostock is also the author of "Outline of the History of the Galvanic Apparatus"; "On the Theory of Galvanism" (*Nicholson's Journal* for 1802); "On the Hypothesis of Galvanism" (*Annals of Philosophy*, III, 1814), and of other works upon different scientific subjects. Reference is made by Mr. William Leithead ("Electricity," London, 1837, Chap. VI. pp. 296, 297) to Bostock's "Elementary System of Physiology," 1827, Vol. II. pp. 413, etc., wherein is shown among other results, that, contrary to the views of Dr. Philip, there is no necessary connection between "the nervous influence" and the action of the glands. At p. 306 of Leithead appears another extract, from the third volume of Bostock, relative to the application of the electro-physiological theory in elucidating the phenomena of disease.

References.—Poggendorff, Vol. I. pp. 249, 250; "Nicholson's Journal," Vols. II. p. 296, and III. p. 3; Figuier, "Expos. et Histoire," 1857, Vol. IV. p. 425; Gilbert, Vol. XII. p. 476.

A.D. 1819.—Hansteen (Christoph) (1784–1873), Norwegian astonomer and physicist, embodies in his notable work, "Untersuchungen über den Magnetismus der Erde . . ." ("Inquiries regarding the magnetism of the earth"), the result of his extensive researches concerning terrestrial magnetism, the account of which is accompanied by a chart indicating the magnetic direction and dip at numerous places. This work, which is said to have been practically completed in 1813 (Humboldt, "Cosmos," 1859, Vol. V. p. 66), was translated by the celebrated Peter Andreas Hansen (Poggendorff, Vol. I. pp. 1013–1015) from the original manuscript and published in German. It attracted much attention throughout the scientific world, and so highly was it thought of that in almost all the voyages of discovery afterwards undertaken most magnetic observations were made according to its directions.

Through the "Encyclopædia Britannica" we learn that Hansteen's able work was first made known in England by Sir David Brewster through two articles in the *Edin. Phil. Journal* for 1820, Vol. III. p. 138, and Vol. IV. p. 114, and that an account of his subsequent researches, drawn up by Hansteen himself, appeared in the *Edin. Journal of Science* for 1826, Vol. V. p. 65. It is also stated that the Royal Society of Denmark proposed in 1811 the prize question, "Is the supposition of one magnetical axis sufficient to account for the magnetical phenomena of the earth, or are two necessary?" Prof. Hansteen's attention had been previously drawn to this subject by seeing a terrestrial globe, on which was drawn an elliptical line round the south pole and marked *Regio polaris magnetica*, one of the foci being called *Regio fortior*, and the other *Regio debilior*. As this figure professed to be drawn by Wilcke, from the observations of Cooke and Furneaux, Hansteen was led to compare it with the facts; and the result of his researches was favourable to that part of Halley's theory which assumes the existence of four poles and two magnetic axes. Hansteen's Memoir, which was crowned by the Danish Society, forms the groundwork of his larger volume published in 1819. "In his fifth chapter, on the Mathematical Theory of the Magnet, he deduces the law of magnetic action from a series of experiments similar to those of Hauksbee and Lambert. . . . In determining the intensity of terrestrial magnetism Professor Hansteen observed that the time of vibration of a horizontal needle varied during the day. Graham had previously suspected a change of this kind, but his methods were not accurate enough to prove it. Hansteen found that the minimum intensity took place between ten and eleven a.m., and the maximum between four and five p.m. He concluded also that there was an annual variation, the

intensity being considerably greater in winter near the perihelion, and in summer near the aphelion; that the greatest monthly variation was a maximum when the earth is in its perihelion or aphelion, and a minimum near the equinoxes; and that the greatest daily variation is least in winter and greatest in summer. He found also that the aurora borealis weakened the magnetic force, and that the magnetic intensity is always weakest when the moon crosses the equator."

According to Dr. Whewell ("History of Induc. Sciences," 1859, Vol. II. p. 226), the conclusions reached by Hansteen respecting the position of the four magnetic "poles" excited so much interest in his own country that the Norwegian Storthing, or Parliament, by a unanimous vote provided funds for a magnetic expedition which he was to conduct along the north of Europe and Asia, and this they did at the very time when, strange to say, they refused to make a grant to the King for building a palace at Christiania. The expedition was made in 1828–1830, and verified Hansteen's anticipations as to the existence of a region of magnetic convergence in Siberia, which he considered as indicating a "pole" to the north of that country. The results were published in Hansteen and Due's "Resultate magnetischer . . ." ("Magn., Astron. and Méteor. Obs. on Journey through Siberia") which appeared in 1863.

In the Sixth Dissertation, Chap. VII of the "Encycl. Brit.," it is said that, next to Prof. Hansteen, science is mainly indebted for the great extension of our knowledge of the facts and the laws of terrestrial magnetism to two illustrious German philosophers, Baron Alexander von Humboldt and Prof. Karl Friedrich Gauss (1777–1855). An account is therein given of Gauss's individual investigations, as well as of the researches he made in conjunction with Wilhelm Eduard Weber (1804–1891), who was likewise a professor at Göttingen. Of Alex. von Humboldt, we have spoken fully under date 1799, and of Gauss and Weber, mention has already been made at Schilling (A.D. 1812).

The very valuable contributions of Gauss and Weber appear throughout all the many scientific publications of the period, notably in the "Abhandlung d. Gött. Geselsch. d. Wiss.," their joint work being shown to advantage in the important "Resultate . . . des Magnet. Vereins," published in Leipzig, 1837–1843.[1]

[1] For Gauss and Weber: Humboldt, "Cosmos," 1849, Vol. I. pp. 172, 185–186; Vol. II. p. 720, and Vol. V, 1859, pp. 63, 71; "Encycl. Brit.," 1879, Vol. X. p. 116, and the 1902 ed. Vol. XXXIII. p. 798; "Am. Journ. of Psych.," Vol. IV. pp. 7–10; "New International Encycl.," 1903, Vol. VIII. p. 159. The following curious array of figures is selected from Gauss' many interesting calculations. He found that the earth's magnetism is such as would result from the existence, in every cubic yard of its mass, of six mag-

REFERENCES.—For M. Hansteen's scientific papers and for an account of additional magnetic results obtained by himself and others, consult the eighth "Britannica," Vols. I. p. 745; IV. p. 249; XIV. pp. 15, 23, 42 (experiment with M. Muschman), 50, 55, 57–64, *et seq.*, for Morlet and others; Thomson's "Outline of the Sciences," London, 1830, pp. 546–548; Whewell, "History of the Induc. Sci.," Vol. II. pp. 613, 615, also p. 219 for Yates and Hansteen; Johnson's new "Univer. Encycl.," 1878, Vol. III. pp. 231–234 for Morlet, etc. : Weld's "Hist. of Roy. Soc.," Vol. II. p. 435; "Edin. Jour. of Sci.," London, 1826, Vols. I. pp. 87, 334; V. pp. 65–71, 218–222; "Report of Seventh Meeting British Association," London, 1838, Vol. VI. pp. 76, 82; J. G. Steinhauser's articles published between 1803 and 1821; Harris' "Rudimentary Magnetism," London, 1852, Part. III. pp. 38, 39, 111; *Phil. Mag.*, Vol. LIX. p. 248, and *Phil. Mag.* or *Annals*, Vol. II. p. 334; "Zeitschr. f. pop. Mitth.," I. p. 33; Schweigger's *Journal*, 1813–1827; Poggendorff's *Annalen*, 1825–1855; "Académie Royale de Belgique" for 1853, 1855, 1865; C. Hansteen and C. Fearnley, "Die Univ.-Sternwarte . . ." 1849; Hansteen, Lundh and Muschman, "Nyt. Mag. for Naturvid," 1823–1856. See likewise his biography in the "English Cyclop. Supplement," pp. 642, 643; "Catal. Roy. Soc. Sc. Pap.," Vol. III. pp. 167–172; Vol. VI. p. 681, Vol. VII. p. 905; Houzeau et Lancaster, "Bibl. Gén.," Vol. II. p. 157; "Edin. Phil. Journal," 1823, Vol. IX. p. 243; "Annual Rec. Sc. Disc.," 1873, p. 683; 1875, p. 155; Knight's "Amer. Mech. Dict.," 1875, Vol. II. p. 1374, and eighth "Britan.," Vol. XIV. p. 49, regarding Hansteen's lines of no variation for 1787; Humboldt's "Cosmos," 1859, Vol. V. pp. 110–111, for the investigations of Hansteen, Sir Ed. Belcher and others, those of the last named being treated of at p. 493 of the *Phil. Trans.* for 1832; Noad, "Manual," pp. 529, 530, 534, 616, 617, etc.; Appleton's "New Am. Cycl.," Vol. XI. p. 64.

A.D. 1819.—Hare (Robert) (1781–1858) who was for twenty-nine years Professor of Chemistry in the Pennsylvania University, publishes in Philadelphia "A New Theory of Galvanism, Supported by Some Experiments and Observations Made by Means of the Calorimotor . . ." of which an English edition appears in London the same year. (A full review of this work is to be found more particularly at p. 206, Vol. LIV of the *Philosophical Magazine*; in the "Encycl. Metropol.," Vol. IV (Galvanism), p. 222; in Ure's "Dictionary of Chemistry," Am. ed., article "Calorimotor"; at p. 187 of the *Phil. Trans.* for 1823; at pp. 409, 410, Vol. I of Gmelin's "Chemistry," and at pp. 413–423, Vol. I of Silliman's *Am. Jour. of Sci.*, the last named being accompanied by a very fine illustration of the Calorimotor.)

This apparatus, which has already been alluded to (Pepys, A.D. 1802), consists of sheets of zinc about 9 inches by 6, and of copper about 14 inches by 6, coiled around one another nearly half an inch apart; there being in all 80 coils, $2\frac{1}{2}$ inches in diameter, which are let down by means of a lever into glass vessels containing the acid solution. Dr. Hare observes :

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netized steel bars, each weighing one pound. Compared with one such magnet, the magnetism of the earth is represented by 8,464,000,000,000,000,000 ("Am. Ann. of Sc. Dis.," 1852, p. iii).

"Volta considered all galvanic apparatus as consisting of one or more electromotors, or movers of the electric fluid. To me it appeared that they were movers of both heat and electricity; the ratio of the quantity of the latter put in motion to the quantity of the former put in motion being as the number of the series to the superficies. Hence the word *electromotor* can only be applicable when the caloric becomes evanescent, and electricity almost the sole product, as in De Luc's and Zamboni's columns; and the word *calorimotor* ought to be used when electricity becomes evanescent and caloric appears the sole product."

"It afterwards appeared quite natural," remarks Mr. W. B. Taylor (Note B, "Mem. of Jos. Henry," p. 376) "to distinguish these classes of effects by the old terms—'intensity' for electromotive force, and 'quantity' for calorimotive force. There is obviously a close analogy between these differences of condition and resultant, and the more strongly contrasted conditions of mechanical and chemical electricity; and indeed the whole may be said to lie in a continuous series, from the highest 'intensity' with minimum quantity, to the greatest 'quantity' with minimum intensity."

Two years later (1821), Dr. Hare constructed his *galvanic deflagrator.* It consists of two pairs of troughs, each ten feet long, and containing 150 galvanic pairs, so arranged that the plates can all be simultaneously immersed into or withdrawn from the acid. Each pair turns on pivots made of iron, coated with brass or copper, and a communication is established between these and the voltaic series within by means of small strips of copper. The "Encyl. Brit." gives a full description of the construction and working of the apparatus, as do also the "Encycl. Metropol.," Vol. IV (Galv.), p. 176; Noad ("Manual," pp. 266, 267); Gmelin ("Chemistry," Vol. I. pp. 409, 410), and Silliman ("Journal of Sci. and Arts," Vol. VII. p. 347). The first-named publication says of Dr. Hare's *deflagrator:*

"A brilliant light, equal to that of the sun, was produced between charcoal points, and plumbago and charcoal were fused by Profs. Silliman and Griscom. By a series of 250, baryta was deflagrated, and a platina wire, three-sixteenths of an inch in thickness, 'was made to flow like water.' In the experiments with charcoal, the charcoal on the copper side had no appearance of fusion, but a crater-shaped cavity was formed within it, indicating that the charcoal was volatilized at this side and transferred to the other, where it was condensed and fused, the piece of charcoal at this pile being elongated considerably. This fused charcoal was four times denser than before fusion. In a letter from Prof. Silliman, which was transcribed in the *Sc. Am. Sup.* for Sept. 21, 1878, he says:

'Undoubtedly the earliest exhibitions of electric light from the voltaic battery were those made with the deflagrators of Dr. Hare by Prof. Silliman at New Haven in 1822, and subsequently on a magnificent scale at Boston in 1834, when an arc of over five inches diameter was produced by the simultaneous immersion of 900 large-sized couples of Hare's deflagrator. But no means had then been devised for the regulation of the electric light to render it constant, and although the writer as early as 1842 used this light successfully to produce daguerreotypes, the progress of invention had yet to make further use of the discovery of science before electrical illumination was possible.' "

The description of Dr. Hare's electrical machine (before alluded to at Van Marum A.D. 1785), wherein the plate is mounted horizontally so as to show both negative and positive electricity, was published in London during 1823, and can be found in Vol. LXII of the *Phil. Mag.*, as well as at pp. 538, 604, 605, Vol. VIII of the 1855 "Encycl. Brit." In the last-named article mention is made of the introduction of a band (illustrated Fig. 7, Plate CCXXII) which prevents the plate from being cracked, as it frequently is, through some hasty effort to put it in motion while it adheres to the cushions. It is also therein stated that in order to offset the heavy expense attending the breakage of large cylinders and plates, M. Walkiers de St. Amand, of Brussels, among many others, made an apparatus of varnished silk 25 feet long and 5 feet wide, capable of giving sparks 15 inches long (see A.D. 1785), while Dr. Ingenhousz constructed machines with pasteboard discs four feet in diameter, soaked in copal or amber varnish dissolved in linseed oil, which gave sparks of one and even two feet in length.

In the fifth volume, new series, of the *Amer. Phil. Trans.* will be found Dr. Hare's "Description of an Electrical Machine," with a plate four feet in diameter, so constructed as to be above the operator; also of a battery discharger employed therewith, and some observations on the causes of the diversity in the length of the sparks erroneously distinguished by the terms positive and negative. Hare is also the inventor of a single gold-leaf electroscope of such great delicacy that it has, he says, enabled him to detect the electricity produced by one contact between a zinc and copper disc, each six inches in diameter (Noad, "Manual," p. 29; Harris' "Rudim. Elect.," p. 50; Silliman's *Journal*, Vol. XXXV). He invented several other electrical appliances, and he is likewise the author of numerous important memoirs which it would be impossible to detail in the narrow limits of this "Bibliographical History." They will, however, be found recorded in the publications named below.

REFERENCES.—*Phil. Trans.* for 1769, Vol. LXIX. p. 659. See also, for Walkiers de St. Amand, the entry at A.D. 1785, as well as Lichtenberg's *Magazin*, Vol. III, 1st, p. 118, for the last-named year. To these might be added the machines made by Mundt, of silken strips (Gren's *Journal der Physik.*, Vol. VII. p. 319); by N. Rouland, "Descript. des mach, elec. à taffetas," Amsterdam, 1785; by Croissant and Thore; of paper by W. H. Barlow (*Phil. Mag,.* Vol. XXXVII. p. 428), of gutta percha; as well as machines of rubber by Fabre and Kunneman, as shown at Th. Du Moncel's "Exposé des appl. de l'El.," second ed., p. 399, and third ed., 1872, Vol. II. pp. 78, 122, 265, besides the peculiarly constructed machines of Erdmann Wolfram (Ferussac, "Bulletin des Sciences Tech." for 1824); of G. H. Seiferheld, "Beschreib . . . elektrische mach," 1787; of F. E. Neuman, as modified by F. Zantedeschi ("Ann. Sci. Lom.-Ven.," XII. p. 73), and of those described at p. 420, Vol. II, and at p. 4, Vol. III of *Nicholson's Magazine*. Consult likewise, pp. 335, 340, second Am. ed. of the "New Edin.' Encycl.," 1817. Poggendorff, Vol. I. pp. 1018, 1019; "Cat. Sci. Papers of Roy. Soc.," Vol. III. pp. 177–182; Vol. VI. p. 182; Silliman's *Am. Jour. Sci. and Arts*, Vols. II. pp. 312, 326; III. p. 105; IV. p. 201; V. p. 94; VII. pp. 103, 108, 351; VIII. pp. 99, 145; X. p. 67; XII. p. 36; XIII. p. 322; XV. p. 271; XXIV. p. 253, XXV. p. 136; XXXI. p. 275; XXXII. pp. 272, 275–278, 280–285; XXXIII. p. 241; XXXV. p. 329; XXXVII. pp. 269, 383; XXXVIII. pp. 1, 336, 339; XXXIX. p. 108; XL. pp. 48, 303; XLI. pp. 1, and XLIII. p. 291; *Phil. Mag.*, Vols. LVII. p. 284; LXII. pp. 3, 8, etc.; *Phil. Mag.* or *Annals*, Vol. VI. pp. 114, 171; *Journal of the Franklin Institute*, third series, Vol. XV. pp. 188, etc.; *Trans. of the Am. Phil. Soc.*, N.S., Vol. VI. p. 297 (for Hare and Allen) also pp. 339, 341, 343, and Vol. VII for 1841; "Mem. Jos. Henry," Washington, 1880, p. 82; Figuier, "Exp. et Hist.," 1857, Vol. IV. pp. 391, 401, 402; Dr. Thomas Thomson, "Outline of the Sc.," London, 1830, pp. 515, 517; Appleton's "New Amer. Cycl.," Vol. VII. p. 66; Appleton's "Dict. of Machines, Mechanics . . ." 1861, pp. 432, 433; Dr. William Henry, "Elem. of Exper. Chem.," London, 1823, Vol. I. p. 169, and Supplement, Chap. VII. p. 29; "Annual of Sc. Disc." for 1862, p. 99.

A.D. 1819.—Gmelin (Leopold), the most distinguished member of the family of that name, publishes, at Frankfort, 1817–1819, the first edition of his celebrated "Handbuch d. theoret. Chemie," which embodies the whole extent of chemical science as it then existed and the fourth and last edition of which, under the author's supervision, appeared during 1843–1845. This extensive work is well known, both in its original form and through the very able translation of it made by Mr. Henry Watts. In the report of the Council of the Chemical Society for 1854, it is said that "the greatest service which Gmelin rendered to science—a service in which he surpassed all his predecessors and all his contemporaries—consists in this: that he collected and arranged in order all the facts that have been discovered in connection with chemistry. His Handbuch der theoret Chemie stands alone. Other writers on chemistry have indeed arranged large quantities of materials in systematic order, but for completeness and fidelity of collation and consecutiveness of arrangement, Gmelin's Handbuch is unrivalled."

Although many references have been made herein to Leopold Gmelin's treatment of such departments of science as directly appeal to the readers of this compilation, it is well to mention some of the headings under which they are to be found. They are, "Electricity," "Electro-chemical Theories," "Electrolysis," "Technical Apparatus of Electricity," "Theory of Galvanism," "Galvanic Batteries," "Magnetic Condition of All Matter," etc., etc., the whole occupying pp. 304 to 519, Vol. I of Gmelin's English edition. The list of many of Leopold Gmelin's valuable contributions to science is given in the "Catalogue Sc. Papers Roy. Soc.," besides which may be mentioned his "Uber e angebl. meteorische masse" (Gilbert, *Annalen*, LXXIII for 1823), and his "Versuch einer elektro-chemisch. theorie" (Poggendorff's *Annalen der Physik und Chemie*, Vol. XLIV for 1838, while at pp. 547–550 of Mr. J. J. Griffin's able work, published in London during 1858, will be found the results obtained by Prof. G. Magnus and by Prof. Faraday with a summary of Gmelin's conclusions under the heading of "The Evidence of Electrolysis in Favour of the Radical Theory."

Gmelin Family

This family, which, through four generations, has been continuously distinguished for its valuable contributions to chemistry as well as to the natural and medical sciences, deserves equally well here of such a special mention as was accorded to the Bernoulli and Cassini families, under dates A.D. 1700 and 1782–1791.

Johann Georg Gmelin (1674–1728), a very able chemist and pharmaceutist of Tübingen, was the father of:

Johann Conrad Gmelin (1707–1759), physician and author in the same city of Tübingen.

Johann Georg Gmelin (1709–1755), distinguished naturalist and chemist, who graduated as M.D. in his nineteenth year, became a member of the St. Petersburg Acad. of Sc. and was sent by the Empress Anna, in company with G. A. Müller and other noted scientists, upon a ten years' exploring expedition through Siberia. He was one of the first explorers of Northern Asia, and a genus of Asiatic plants was named Gmelina after him by Linnæus.

Philip Friedrich Gmelin (1722–1768), Professor of Botany and of Chemistry at Tübingen, author of many scientific monographs.

Samuel Gottlieb Gmelin (1744–1774), elder son of Philip Friedrich, who, like his uncle, graduated M.D. at nineteen and was sent

two years later by the Empress Catherine II upon a scientific tour through South-Eastern Russia, is the author of "Historia Fucorum . . ." as well as of other contiibutions which were edited through the famous Pallas. His biographical notice appears in the last volume of the "Reise durch Russland . . ." published at St. Petersburg.

Johann Friedrich Gmelin (1748–1804), M.D., succeeded his father, Philip Friedrich, in the chair of chemistry and botany at the Tübingen University, became Professor of Medicine at Göttingen in 1778 and a member of "l'Académie des Curieux de la Nature." He is the author of the thirteenth edition of Linnæus' "Systema Naturæ," which, notwithstanding Cuvier's severe criticism of it, is said to be the only work which even professes to embrace all the objects of natural history described up to the year 1790 ("Encycl. Brit.," 1855, Vol. IX. p. 4). He is also the author of "Geschichte der Chemie . . ." Göttingen, 1797–1799, and of "Prælectio de col. metal. a Volta . . ." ("Commentat. Soc. Gött." XV (Phys.) for 1800–1803, p. 38). (See J. C. Poggendorff, "Biogr.-Literar. Handwörterbuch," Vol. I. pp. 914–915.)

His son, Leopold Gmelin (1788–1853), who has already been noticed, practised chemical manipulation in the Tübingen pharmaceutical laboratory of Dr. Christian Gmelin, the son of Johann Conrad, and studied at Göttingen, Vienna and in Italy, after which he became medical and chemical professor at Heidelberg, 1817–1851 (Poggendorff, Vol. I. pp. 915–916).

Ferdinand Gottlob von Gmelin (1782–1848), elder son of Dr. Christian Gmelin, was Professor of Medicine and of Natural History in the Tübingen University, and wrote "Diss. sistens obs. phys. et chem. de electricitate et galvanismo" during 1802 (Poggendorff, Vol. I. pp. 916–917).

Christian Gottlob Gmelin (1792–1860), brother of the last named, M.D., was Professor of Chemistry and Pharmacy at the Tübingen University, and the author of "Experimenta electricitatem . . ." 1820; "Uber d. Coagulat. . . . d. Electricität" (Schweigger's "Journal," Vols. XXXVI for 1822); "Analyse d. turmalins . . ." (Schweigger's "Journal," Vols. XXXI for 1821 and XXXVIII for 1823—Poggendorff's "Annalen," Vol. IX for 1827), as well as of a "Handbuch der Chemie," published 1858–1861 (Poggendorff, Vol. I. p. 917; *Phil. Mag.* or *Annals*, Vol. III. p. 460).

References.—Gmelin and Schaub, "Effets Chimiques de la col. metal . . ." ("Magas. Encyclop.," Vol. VI. p. 201); Eberhard Gmelin's letter to M. Privy Councillor Hoffmann of Mayence (1787), and his new investigations (1789) on the subject of animal magnetism ("Salzb. Med. Chir. Zeit.," 1790, I. p. 358); Whewell, "Hist. of the Ind. Sc.," 1859, Vol. II. p. 348.

A.D. 1819.—Dana (J. F.), M.D. (1793–1827), Chemical Assistant in Harvard University and Lecturer on Chemistry and Pharmacy in Dartmouth College, writes, Jan. 25, 1819, to Prof. Benjamin Silliman concerning his new form of portable electrical battery.

This apparatus, consisting of alternate plates of flat glass and of tinfoil, the sheets of which latter are connected together, is fully described at pp. 292–294, and is illustrated opposite p. 288, Vol. I of Silliman's *American Journal of Science*, 1818, wherein it is stated that, while "in a battery of the common form, 2 feet long, 1 foot wide and 10 inches high, containing 18 coated jars, there will be no more than 3500 square inches of coated surface," a battery of Dana's construction will have no less than 8000 square inches covered with tinfoil, allowing the sheet of glass and of foil to be a quarter of an inch thick. In a brief description of this apparatus, which appears at p. 468, Vol. V of Tilloch's *Phil. Mag. and Journal*, it is stated that a "battery constructed in this way contains, in the bulk of a quarto volume, a very powerful instrument; and when made of glass it is extremely easy, by varnishing the edges, to keep the whole of the inner surfaces from the air, and to retain it in a constant state of dry insulation."

A.D. 1820.—Oersted—Örsted (Hans Christian), native of Denmark (1770–1851), Professor of Natural Philosophy and founder of the Polytechnic School in Copenhagen, makes known, through a small four-page pamphlet entitled "Experimenta circa effectum conflictus electrici in acum magneticam," his great discovery of the intimate relation existing between electricity and magnetism (Thomson's *Annals of Philosophy* for October 1820, Vol. XVI, first series, pp. 273–276). He thus lays the foundation of the science of electro-magnetism, which subsequently was so materially developed by Ampère and Faraday.

It is said that after taking his doctor's degree in 1799, he gave much attention to galvanism, and that in the year 1800 he made important discoveries as to the action of acids during the production of galvanic electricity. He was one of the earliest to show the opposite conditions of the poles of the galvanic battery, also that acids and alkalies are produced in proportion as they neutralize each other. Upon his return from a trip to France and Germany, 1801–3, he lectured on electricity and the cognate sciences, publishing thereon a number of essays. (These are to be found, more particularly, in J. H. Voigt's *Magazin*, Vol. III. p. 412; Van Mons' *Journal*, No. IV. p. 68; the *Bulletin of the Société Philomathique*, No. LXVII. an. xi. p. 128; A. F. Gehlen's *Neues Allgem. Journal d. Chemie*, Vols. III for 1804, VI for 1806, VIII for 1808; Schweigger's

Journal, Vol. XX; *Phil. Mag.*, Vol. XXIII. p. 129; the "Skand. Lit.-Selskabs Skrifter," Vol. I; "Oversigt over det Kongl. . . . Forhandlinger," 1814–1815; "Nyt Biblioth. f. Physik," etc., Vol. IX, and in the *Journal de Physique* as well as in the *Journal du Galvanisme*.)

He revisited Germany during 1812, and, at the suggestion of Karsten Niebuhr, published in Berlin his work "Ansicht der Chemischen Naturgesetze. . . ." ("Inquiry into the identity of chemical and electric forces"), a translation of which was made by M. P. Marcel T. de Serres under the title of "Recherches sur l'Identité. . . ." (Fahie, "Hist. of Electric Teleg.," 1884, pp. 270–273). The last-named work appeared at Paris during 1813, and not, as stated at p. 41, Vol. LVII of the *Philosophical Magazine*, during 1807, which was the date of the original small German edition.[1]

One of his biographers says that Oersted was lecturing one day to a class of advanced students, when, as a means of testing the soundness of the theory which he had long been meditating, it occurred to him to place a magnetic needle under the influence of a wire uniting the ends of a voltaic battery in a state of activity. "In galvanism," said he, "the force is more latent than in electricity, and, still more so in magnetism than in galvanism; it is necessary therefore to try whether electricity, in its latent state, will not affect the magnetic needle." He tried the experiment upon the spot and found that the needle tended to turn at right angles to the wire, thus proving the existence of electro-magnetism, or the relation of electricity and magnetism as mutually productive of each other, and as evidences of a common source of power. Previous to this time the identity of magnetism and electricity had only been suspected. For several months Oersted prosecuted experiments on the subject, and on the 21st of July 1820 promulgated his discovery through the Latin pamphlet above alluded to. Therein he contends that there is always a magnetic circulation around the electric conductor, and that the electric current in accordance

[1] Whewell, "Hist. of Induc. Sci.," 1859, Vol. II. p. 244. It paved the way for his subsequent identification of the forces of electricity, galvanism and magnetism.

Prof. W. B. Rogers remarks that attempts to discover this connection had been made with galvanic piles or batteries whose poles were not connected by conductors, under the expectation that these would show magnetical relations, although in such cases the electricity accumulated at the extremities was evidently stagnant. It was reserved for Oersted first to bring into prominent view the fact that it was not while the electricity was thus at rest, but while it was flowing through the wire connecting the two poles, that it exhibited magnetic action, and that a wire thus carrying a current, while it had the power of affecting a magnetic needle, was in turn susceptible of being acted on by a magnet; and this was the initial step in the science of electro-magnetism.

with a certain law always exercises determined and similar impressions on the direction of the magnetic needle, even when it does not pass through the needle but near it (the eighth edition of the "Encycl. Britannica," Fifth Dissertation, pp. 739, 740, 745; and the Sixth Dissertation, pp. 973–976; Schaffner, "Tel. Manual," 1859, Chap. VIII; *Practical Mechanic*, Glasgow, 1842, Vol. III. p. 45).

For this discovery, which naturally excited the wonder of the entire scientific world, he received the Copley medal of the English Royal Society, the Dannebrog order of knighthood and numerous testimonials from nearly every quarter of Europe. As observed by Mr. J. D. Forbes (Sixth Disser. "Encycl. Brit.," Vol. I), "the *desideratum* of a clear expression of the manifest alliance between electricity and magnetism has been so long and so universally felt that the discovery placed its author in the first rank of scientific men. . . . The prize of the French Institute, which had been awarded to Davy for his galvanic discoveries, was bestowed upon Oersted."

Oersted's experiments were repeated before the French Academy of Sciences by M. De la Rive on Sept. 11, 1820, and, seven days later, as we shall see, Ampère made known the law governing electro-magnetism (Mme. Le Breton, "Hist. et. Appl. de l'Elect.," Paris, 1884, pp. 72, 73; W. Sturgeon, "Sci. Researches," Bury, 1850, p. 18; Higg's Translation of Fontaine's "Electric Lighting," London, 1878, p. 54).

The many investigations subsequently carried on by Oersted in different branches of sciences are alluded to in the works named below. Perhaps the most interesting, outside of the ones already spoken of, are those attaching to thermo-electricity which he made in conjunction with Baron Fourier, and independently of Dr. Seebeck.

References.—Eighth "Britannica," pp. 651 and 652, Vol. XXI, as well as pp. 11 and 12, Vol. XIV of Oersted's "Efterretning om nogle nye, af Fourier og Oersted . . ." Kiobenhaven, 1822–1823, translated into French as mentioned in Vol. XXII of the *Annales de Chimie et de Physique*; "Oversigt over det Kongl. . . ." for 1822–1823 and 1823–1824; Poggendorff, Vol. III. pp. 309–312; "Catal. Sci. Papers Roy. Soc.," Vol. I. pp. 697–701; Biog. Sketch by P. L. Möller, "Oersted's Character und Leben," 1851, also Hauch und Forchammer, 1853; Obituary notice in *Jour. Frankl. Inst.*, 1851, Vol. XXI. p. 358; Humboldt, "Cosmos," 1849, Vol. I. pp. 182, 185 and the 1819–1820 entry of "Magnetic Observations," in Vol. V; "Oversigt over det Kongl. danske Videnskabernes Selskabs Fordhandlinger" for 1822, 1832, 1834–1835, 1836–1837, 1840–1842, 1847–1849; Poggendorff's *Annalen*, Vol. LIII; "Ursin's Magaz. f. Kunstnere . . ." Vols. I and II; "Dict. of Electromagn.," 1819; Sturgeon's *Annals of Electricity*, Vol. I. p. 121; Hatchett "On the Experim. . . . of Oersted and Ampère" (*Phil. Mag.*, Vol. LVII. p. 40), *Phil. Mag.*, Vols. LVI. p. 394; LVII. pp. 47–49; LIX. p. 462; *Phil. Mag.* or *Annals*,

Vol. VIII. p. 230; *Annales de Chimie* for Aug. 1820, p. 244; S. S. Eyck, "Over de magnetische. . . ." (*Bibl. Univ.*, 1821); Translation by H. Sebald, of H. C. Oersted's "Leben," 1853; Michaud, "Biog. Univ.," Vol. XXXI. p. 196; P. L. Möller, "Der Geist in der Natur" ("The Spirit in Nature"); Elie de Beaumont, "Memoir of Oersted" ("Smith. Rep." for 1863); Gilbert's *Annalen*, Vol. LXVI. p. 295, 1820; Callisen, "Medicinisches Schriftseller-Lexikon"; W. Sturgeon's "Sci. Researches," Bury, 1850, p. 8 (for 1807), and pp. 9–12 for English version of Oersted's pamphlet which was translated in German in Vol. XXIX of Schweigger's "Journal," as well as in Vol. LXVI of Gilbert's *Annalen*, and which appeared in French in Vol. XIV of the *Annales de Chimie et de Physique* for 1820, as well as in Vol. II. pp. 1–6 of "Collection de Mémoires relatifs à la Physique," Paris, 1885. See also "Biogr. Gén.," Vol. XXXVIII. pp. 522–535; "Göttinger Gelehrte Anz.," No. 171; Sturgeon's "Sc. Researches," pp. 17, 18, 28, 415; Thomson's "Annals of Philosophy," Vol. XVI. p. 375 for second series of observations; Van Marum on "Franklin's Theory of Electricity," pp. 440–453; "Galvanism," by Mr. John Murray, p. 467; "Note sur les expériences . . . de Oersted, Ampère, Arago, et Biot," (*Annales des Mines*, 1820); L. Turnbull, "Elec. Mag. Tel.," 1853, pp. 45, 221; J. F. W. Herschel's "Preliminary Discourse," 1855, pp. 244, 255; Fahie, "Hist. Elec. Tel.," 1884, pp. 270–275, Harris, "Rud. Elec.," 1853, p. 171; Ostwald's *Klassiker*, No. 63 and "Elektrochemie," 1896, p. 67; Mrs. Somerville, "Con. of Phys. Sci.," 1846, p. 314; Noad, "Manual," p. 642; "Lib. Useful Know." (El Magn.), pp. 4, 79; Lardner's "Lectures," 1859, Vol. II. p. 119; Tomlinson's "Cycl. Useful Arts," Vol. I. p. 559; Ure's "Dict. of Arts," 1878, Vol. II. p. 233; Henry Martin's article in Johnson's "New Cyclopædia," 1877, Vol. I. pp. 1512, 1514; "Nyt Biblioth. f. Physik," Band I auch Scherer's Nord. Arch., II; "Tidskrift f. Natur . . ." I 1822: Schumacher's "Astron. Jahrbuch" for 1838; L. Magrini, "Nuovo metodo. . . ." Padova, 1836; Boisgeraud "On the Action of the Voltaic Pile . . ." (*Phil. Mag.*, Vol. LVII. p. 203); *Sci. Am. Suppl.*, No. 454, p. 7241; Schweigger's *Journal*, Vols. XXXII, XXXIII, LII; Figuier, "Expos. et Hist.," 1857, Vol. IV. p. 393; "Engl. Cycl.," "Arts and Sci.," Vol. III. p. 782; Brande's "Man. of Chem.," London, 1848, Vol. I. p. 248; Prime's "Life of Morse," pp. 264, 451; Dr. Henry's "Elm. of Exper. Chem.," London, 1823, Vol. I. pp. 193–203; *Jour. of the Frankl. Inst.* for 1851, Vol. XXI. p. 403; "*La Lumière Electrique*" for Mar. 19, 1887, p. 593, and for Oct. 31, 1891, pp. 201, etc.: Sir William Thomson, "Math. Papers," reprint, etc., 1872; "Encyl. Metrop." (Elect. Mag.,); G. B. Prescott, "Elect. and the El. Tel.," 1885, Vol. I. p. 91; "Smithsonian Report" for 1878, pp. 272, 273, note; Bacelli (L. G.), "Risultati . . ." Milano, 1821; "Bibl. Britan.," Vol. XVII, N.S. p. 181; Vol. XVIII, N.S. p. 3; "Edin. Phil. Journal," Vol. X. p. 203; "Journal of the Soc. of Tel. Eng.," 1876, Vol. V. pp. 459–464, for a verbatim copy of Oersted's original communication on his discovery of electro-magnetism, and pp. 464–469 for a translation thereof by the Rev. J. E. Kempe under the title of "Experiments on the effect of electrical action on the Magnetic Needle.". For the interesting electro-magnetic experiments of J. Tatum, at this same period, consult the *Phil. Mag.*, Vol. LVII, 1821, p. 446; Vol. LXI, 1823, p. 241; Vol. LXII, 1823, p. 107, and, for additional investigation, the Vols. XLVII and LI for years 1816 and 1818.

A.D. 1820.—On Oct. 9, M. Boisgeraud, Jr., reads, before the French Académie des Sciences, a paper concerning many of his experiments, which prove to be merely variations of those previously made by Oersted.

He observed that connecting wires, or arcs, placed anywhere in the battery, affect the needle, and he noticed the difference of in-

tensity in the effects produced when electrical conductors are employed to complete the circuit. He proposed to ascertain the conducting power of different substances by placing them in one of the arcs, cells or divisions of the battery, and bringing the magnetic needle, or Ampère's galvanometer, toward another arc, viz. to the wire or other connecting body used to complete the circuit in the battery. With regard to the positions of the needle and wire, as observed by Boisgeraud, they are all confirmatory of Prof. Oersted's statement ("Ency. Met." (Electro.-Mag.), Vol. IV. p. 6).

One month later, Nov. 9, 1820, Boisgeraud reads, before the same Académie, his paper "On the Action of the Voltaic Pile upon the Magnetic Needle," which will be found on pp. 203–206 and 257, 258, Vol. LVII of the *Philosophical Magazine.*

A.D. 1820.—Banks (Sir Joseph) (1743–1820), a very eminent English naturalist and traveller, to whom reference has been made under the A.D. 1775 date, deserves mention here were it alone for the fact that while occupying the presidential chair of the Roy. Soc., during the extraordinary long and unequalled period of over *forty-two years* (1777, date of Sir John Pringle's retirement, to 1820, the date of President Banks' death) he was instrumental in bringing prominently before the world many of the most important discoveries and experiments known in the annals of magnetism and electricity.

Sir Joseph Banks was succeeded in the presidency of the Royal Society by William Hyde Wollaston, M.D., June 29, 1820, and by Sir Humphry Davy, Bart., Nov. 30, 1820, the last named holding the office seven years (R. Weld, "Hist. Roy. Soc.," 1848, Vol. II. p. 359). Banks and Dr. Solander, the pupil of Linnæus, had sailed (1768–1771) with Captain Cook in his voyage around the globe, in the capacity of naturalists, and afterwards (1772) visited Iceland, where they made many important discoveries. In 1781 Banks was created a baronet; he received the Order of the Bath in 1795 and subsequently had many honours conferred upon him by different English and foreign societies. It is said that he was never known to be appealed to in vain by men of science, either for pecuniary assistance or for the use of his extensive library.

REFERENCES.—Tilloch's *Phil. Mag.* for 1820, Vol. LVI. pp. 40–46; "Cat. Sci. Papers Roy. Soc.," Vol. I. p. 176; Dr. Thomas Thomson, "Hist. Roy. Soc.," London, 1812, p. 12; *Gentleman's Magazine* for 1771, 1772 and 1820; "Biog. Univ.," Vol. LVII, Suppl. p. 101; Larousse, "Dict. Univ.," Vol. II. p. 155; "Eloge Historique de Mr. J. Banks, lu à la Séance de l'Académie Royale des Sciences, le 2 Avril 1821"; Sir Everard Home, "Hunterian Oration," Feb. 14, 1822. See besides, the *Phil. Mag.*, Vol. LVI. pp. 161–174, 241–257; for "A review of some of the leading points in the official character and proceedings of the late President of the Royal Society," contrasting the respective personal

merits and achievements of Sir John Pringle and of Sir Joseph Banks; "Lives of Men of Letters and Science," by Henry, Lord Brougham, Philad., 1846, pp. 199–229, 294–295.

A.D. 1820.—Barlow (Peter), F.R.S. (1776–1827), who taught mathematics at the Military Academy of Woolwich from 1806 to 1847, brings out the first edition of his "Essay on Magnetic Attractions, Particularly as Respects the Deviation of the Compass on Shipboard Occasioned by the Local Influence of the Guns, etc., with an Easy Practical Method of Observing the Same in all Parts of the World." One of his biographers states that through this valuable publication, which received the Parliamentary reward from the then existing Board of Longitude, as well as presents from the Russian Emperor, he was the first to reduce to strictly mathematical principles the method of compensating compass errors in vessels (*Edin. Jour. of Sci.*, London, 1826, Vols. I. pp. 181, 182; II. p. 379).

This work contains the results of the many experiments to ascertain the influence of spherical and other masses of iron upon the needle, which Barlow instituted, more particularly after Prof. Hansteen's investigations became generally known. Sir David Brewster details Barlow's work in the "Encycl. Brit.," and refers to the separate observations of Mr. Wm. Wales (at A.D. 1774), Mr. Downie (at A.D. 1790), Captain Flinders (at A.D. 1801), and Charles Bonnycastle (at A.D. 1820), mentioning the fact that it is to Mr. W. Bain we owe the distinct establishment and explanation of the source of error in the compass arising from the attraction of all the iron on board of ships. The small 140-page book which Mr. Bain published on the subject in 1817 is entitled "An Essay on the Variation of the Compass, Showing how Far it is Influenced by a Change in the Direction of the Ship's Head, with an Exposition of the Dangers Arising to Navigators from not Allowing for this Change of Variation." Brewster remarks that additional light was thrown upon Mr. Bain's observations by Captains Ross, Parry and Sabine, but that we owe to Prof. Barlow alone a series of brilliant experiments which terminated in his invention of the neutralizing plate for correcting in perfect manner this source of error in the compass (Noad's "Manual," pp. 531, 532; Olmstead's "Introduct. to Nat. Hist.," 1835, pp. 206, 210). The simple contrivance therein alluded to is described and illustrated at pp. 9 and 90–91 of the "Britannica," article on "Navigation," and may briefly be said to consist of only a thin circular plate of iron placed in a vertical position immediately behind the binnacle or compass (Fifth Dissertation of "Britannica," Vol. I. p. 745, and article "Seamanship," in Vol. XX. p. 27). Such plates were immediately tried in all parts of the world and were

at once applied to the English vessels "Conway," "Leven" and "Barracouta" (*Trans. Soc. of Arts* for 1821, Vol. XXXIX. pp. 76–100; Harris' "Rud. Mag.," III. pp. 69–76; John Farrar, "Elem. of El. . . ." 1826, pp. 376–383; *Westminster Review* for April 1825; "Encycl. Metropol.," Vol. III (Magnetism), pp. 743, 799).

For Mr. Barlow's experiments on the influence of rotation upon magnetic and non-magnetic bodies, the result of which was communicated by him to the Royal Society, April, 14, 1825, six days before the receipt of S. H. Christie's paper "On the Magnetism of Iron, Arising from its Rotation," communicated by J. F. W. Herschel, see pp. 10, 33, 34, of the "Britannica," Vol. XIV above referred to (*Edin. Jour. of Science*, 1826, Vols. III. p. 372, and V. p. 214. Consult also, J. Farrar, "Elem. of El.," 1826, pp. 387–395. For his extensive observations regarding the influence of heat on magnetism and relative to the variation, as well as for the mode of constructing his artificial magnets, consult the same volume of the "Britannica," at pp. 35, 36, 50–53 *et seq.* and p. 73. See likewise, for the variation, Dr. Thomas Thomson's "Outline of the Sciences," London, 1830, pp. 549–556; Harris, "Rud. Mag.," I, II. pp. 152–153. For Samuel Hunter Christie, consult "Abstracts of Papers . . . Roy. Soc.," Vol. II. pp. 197, 225, 243, 251, 270, 305, 321, 347 and 351).

The new variation chart which Prof. Barlow constructed and in which he embraced the magnetic observations made in 1832 by Sir James Ross, R.N., is described and illustrated in *Phil. Trans.* for 1833, pp. 667–675, Plates XVII, XVIII. He remarks that the very spot where his officer found the needle perpendicular, "that is, the pole itself, is precisely that point in my globe and chart in which, by supposing all the lines to meet, the several curves would best preserve their unity of character, both separately and conjointly as a system" (eighth "Britan.," Vol. XIV, note, p. 50; Noad, "Manual," p. 617; D. Olmstead, "Intr. to Nat. Phil.," 1835, p. 192).

Mr. Barlow's electro-magnetic globe was exhibited by Dr. Birkbeck in his lectures on "Electro-Magnetism" at the London Institution, May 26, 1824. (Its construction is fully described, more particularly, at p. 65 of the English "Encycl. Brit." (Magnetism); p. 91 of the "Lib. of Useful Knowledge" (Electro-Magnetism); pp. 139–140, Vol. I of the *Edin. Jour. of Science*, London, 1826, and pp. 120–122, Part III of Harris' "Rud. Mag.") Its purpose was to show that what had hitherto been considered as the magnetism of the earth might be only modified electricity, and it was also intended to illustrate the theory advanced by M. Ampère, who, as is well known, attributed all magnetic phenomena to electric currents. In the words of Dr. Brewster :

"Barlow considers it as probable that magnetism as a distinct quality has no existence in Nature. As all the phenomena of terrestrial magnetism can be explained on the supposition that the magnetic power resides on its surface, it occurred to Mr. Barlow that if he could distribute over the surface of an artificial globe a series of galvanic currents in such a way that their tangential power should everywhere give a corresponding direction to the needle, this globe would exhibit, while under electrical induction, all the magnetic phenomena of the earth upon a needle freely suspended above it. Mr. Barlow says 'he has proved the existence of a force competent to produce all the phenomena without the aid of any body usually called magnetic,' yet he acknowledges that 'we have no idea how such a system of currents can have existence on the earth, because, to produce them, we have been obliged to employ a particular arrangement of metals, acids, and conductors.'"

Barlow was the first to test the practicability of Ampère's suggestion that by sending the galvanic current through long wires connecting two distant stations, the deflections of enclosed magnetic needles would constitute very simple and efficient signals for an instantaneous telegraph (*Ann. de Chimie et de Phys.*, 1820, Vol. XV. pp. 72, 73). He has thus stated the result: "In a very early stage of electro-magnetic experiments, it had been suggested (by Laplace, Ampère and others) that an instantaneous telegraph might be established by means of conducting wires and compasses. The details of this contrivance are so obvious, and the principle on which it is founded so well understood, that there was only one question which could render the result doubtful; and this was, is there any diminution of effect by lengthening the conducting wires? It had been said that the electric fluid from a common (tinfoil) electric battery had been transmitted through a wire four miles in length without any sensible diminution of effect, and, to every appearance, instantaneously; and if this should be found to be the case with the galvanic circuit, then no question could be entertained of the practicability and utility of the suggestion above adverted to. I was therefore induced to make the trial; but I found such a sensible diminution with only 200 feet of wire, as at once to convince me of the impracticability of the scheme. It led me, however, to an inquiry as to the cause of the diminution, and the laws by which it is governed." This passage is quoted in "Smithsonian Report" for 1878, p. 279; Fahie, "Hist. El. Tel.," p. 306; "Memor. of Jos. Henry," 1880, pp. 223, 224, the last named containing the following footnote: "On the Laws of Electro-Magnetic Action," *Edinburgh Philosophical Journal*, Jan., 1825, Vol. XII. pp. 105–113:

"In explanation and justification of this discouraging judgment

from so high an authority in magnetics, it must be remembered that both in the galvanometer and in the electro-magnet, the coil best calculated to produce large effects was that of least resistance; which unfortunately was not that best adapted to a long circuit. On the other hand the most efficient magnet or galvanometer was not found to be improved in result by increasing the number of galvanic elements. Barlow in his inquiry as to the law of diminution was led (erroneously) to regard the resistance of the conducting wire as increasing in the ratio of *the square* root of its length" (pp. 110, 111 of the last-cited "Journal."

Mr. Taylor justly adds that subsequent experiments have proved Ohm's law (announced three years after Barlow's) of a simple ratio of resistance to length as approximately correct.

References.—G. B. Prescott, "The Speaking Telephone," 1879, II; *Sci. Am. Supp.*, Nos. 405, p. 6466; 453, p. 7235; 547, p. 8735: "Mem. of Jos. Henry," 1880, pp. 83, 94, 144, 485, 487. See also, Poggendorff, Vol. I. pp. 102, 103; Whewell, "Hist. Ind. Sciences," 1859, Vol. II. pp. 223, 224, 245, 254, 616; "Lib. Useful Knowledge" (Magnetism), p. 86 and (El. Mag.), pp. 7, 18, 22, 28; Sturgeon's "Sci. Researches," Bury, 1850, pp. 26, 29, 31, 298; Humboldt, "Cosmos," 1849, Vol. I. p. 183; Mrs. Somerville, "On the Earth not a Real Magnet," in the "Conn. of the Phys. Sci.,"; *Phil. Mag.*, Vols. LV. p. 446; LX. pp. 241, 343; LXII. p. 321; Harris, "Rud. Mag.," Part III. pp. 114–116; "Encycl. Metropol.," Vol. IV (Elect. Mag.), pp. 1–40; "Abstracts of papers . . . Roy. Soc.," Vol. II. pp. 164, 197, 241, 318; "Cat. Sc. Papers . . . Roy. Soc.," Vol. I. pp. 182–184; "Bibl. Britan.," Vol. XX, N.S. p. 127; "Edin. Phil. Journal," 1824, Vol. X. p. 184 (alludes to papers of Barlow and Christie in *Phil. Trans.* for 1823, Part II).

Mr. Wm. Henry Barlow, second son of Peter Barlow, is the author of a treatise, "On the spontaneous electrical currents observed in the wires of the electric telegraph," which was published in London during 1849 and appeared in Part I of the *Phil. Trans.*, for that year. He is also the inventor of a new electrical machine alluded to herein at Hare (A.D. 1819), also at p. 130 of the "Annual of Sc. Disc.," at pp. 76–77 of Noad's "Manual," and at p. 428, Vol. XXXVII of the "Philosophical Magazine."

A.D. 1820.—Laplace (Pierre Simon, Marquis de) (1749–1827), a very distinguished French astronomer and mathematician, suggests for telegraphic purposes the employment of magnetic needles suspended in multipliers of wire, in place of the voltameters of Sömmering, and on the 2nd of October 1820 his theory is thus explained by Ampère in a paper read before the French Academy of Sciences:

"According to the success of the experiment to which Laplace drew my attention, one could, by means of as many pairs of live

wires and magnetic needles as there are letters of the alphabet, and by placing each letter on a separate needle, establish, by the aid of a distant pile, and which could be made to communicate by its two extremities with those of each pair of conductors, a sort of telegraph, which would be capable of indicating all the details that one would wish to transmit through any number of obstacles to a distant observer. By adapting to the battery a keyboard whose keys were each marked with the same letters and establishing connection (with the various wires) by their depression, this means of correspondence could be established with great facility, and would only occupy the time necessary for pressing down the keys at the one station and to read off the letters from the deflected needles at the other."

Laplace is, perhaps, best known by his "Traité de Mécanique Céleste," the sixteen books and supplements to which are by many considered, next to Newton's "Principia," the greatest of astronomical works; a book which has been truly said to have had no predecessor and which has been called the crowning glory of Laplace's scientific career. His next important work was the "Théorie Analytique des Probabilités," the most mathematically profound treatise on the subject which had yet appeared, while his "Système du Monde" was called by Arago "one of the most perfect monuments of the French language." By Prof. Nichols, Laplace is called "the titanic geometer"; by Mr. Airy "the greatest mathematician of the past age"; by Prof. Forbes "a sort of exemplar or type of the highest class of mathematical natural philosophers of this, or rather the immediately preceding age."

Laplace also wrote, in conjunction with Lavoisier, a treatise "On the Electricity which Bodies Absorb when Reduced to Vapor" (*Mém. de Paris* for 1781). Prof. Denison Olmstead, treating of the origin of atmospherical electricity ("Introd. to Nat. Phil.," 1835, pp. 158, 159), says: "Among the known sources of this agent none seems so probable as the evaporation and condensation of watery vapor. We have the authority of two of the most able and accurate philosophers, Lavoisier and Laplace, for stating that bodies in passing from the solid or liquid state to that of vapor, and, conversely, in returning from the aeriform condition to the liquid or solid state, give unequivocal signs of either positive or negative electricity," and he adds, in a footnote:

"M. Pouillet has lately published a set of experiments, which seems to overturn Volta's theory of the evolution of electricity by evaporation. He has shown that no electricity is evolved by evaporation unless some chemical combination takes place at the same time . . ." (Thomson, "Outlines," p. 440) . . . "But we shall

be slow to reject the results of experiments performed by such experimenters as Lavoisier and Laplace, especially when confirmed by the testimony of Volta and Saussure."

With regard to the origin of meteorites, Laplace has advanced the very bold theory that they may be products of Lunar volcanoes, and Prof. Lockhart Muirhead stated that he would "present the reasoning upon which this extraordinary hypothesis is founded in the popular and perspicuous language of Dr. Hutton, of Woolwich: the respect due to the name of Laplace justifying the length of the extract," which he gives at pp. 633–635, Vol. XIV of the 1857 "Britannica."

References.—Humboldt, "Cosmos," London, 1849, Vol. I. pp. 108–109; Young, "Course of Lectures," London, 1807, Vol. II. p. 501, alluding to "Zach. Mon. Corr.," VI. p. 276, also to Gilbert, XIII. p. 353, 108, and stating that Olbers had suggested Laplace's idea in 1795. See "Mem. of the Astronom. Soc. of London," Vol. III. p. 395: Laplace, "Mem. de l'Institut" for 1809, p. 332; Dr. Young's "Course of Lectures," 1807, Vol. I. pp. 249, 250, 522; Vol. II. p. 466; Humboldt, "Cosmos," London, 1849, Vol. I. pp. 28, 76, 130; Vol. II. p. 712; Lavoisier at A.D. 1781: Biot at A.D. 1803; *Annal. de Ch. et Phys.*, Vol. XV. pp. 72, 73, and for Laplace and Lavoisier, see Delaunay, "Manuel . . ." 1809, p. 178; "Mem. de l'Acad. des Sc.," for 1781; "Journal des Savants," for Feb. 1850 and Nov. 1887; Houzeau et Lancaster, "Bibl. Gén.," Vol. II. p. 184; "Cat. Sc. Pap. Roy. Soc.," Vol. III. pp. 845–848; Johnson's "Cyclopædia," pp. 1647–1650 and the "First Supplement," p. 62.

For Laplace and Joseph Louis Lagrange, see "Mémoires de l'Institut," Vol. III. p. 22; also "Pioneers of Science," by Sir Oliver Lodge, London, 1905, Lecture XI, and for Lagrange, consult "Journal des Savants," Sept. 1844, May 1869, August 1878, Sept. 1879, Sept. 1888 and Oct. 1892.

M. Cyrille Pierre Théodore Laplace, captain in the French navy, is the author of the "Voyage Autour du Monde . . . sur la Corvette *Favorite* . . ." and of "Campagne de Circumnavigation de la Frégate *l'Artémise* . . ." published in Paris during the years 1833, 1839 and 1841.

Baron Jean Baptiste Fourier, celebrated French physicist (1768–1830) who, in 1827, succeeded Laplace as head of the Council of the Ecole Polytechnique ("Biog. Gén.," Vol. XVIII. p. 346) says of his predecessor:

"Posterity, which has so many particulars to forget, will little care whether Laplace was for a short time minister of a great state. The eternal truths which he has discovered, the immutable laws of the stability of the world, are of importance, and not the rank which he occupied" (C. R. Weld, "Hist. Roy. Soc.," Vol. II. p. 465). Fourier is the author of "Expériences thermo-électriques" ("Encycl. Brit.," ninth ed., Vol. IX. p. 490; "Eng. Cycl.," Biography, Vol. II. p. 977).

A.D. 1820.—Dutrochet (René Joachim Henri) (1776–1847) a distinguished French natural philosopher, and likewise medical adviser to the King of Spain, Joseph Bonaparte, publishes an interesting treatise on meteors, in conjunction with Mr. Nathaniel Bowditch, who had already written many very able papers on astronomical subjects and who afterwards translated the " Mécanique Céleste " of Laplace. Eight years later (1828) appeared Dutrochet's " Nouvelles Recherches . . ." wherein he attributes to electricity the direction taken by fluids through animal and vegetable membranes. The passage of a fluid from without inwardly he called *endosmosis*, and the passage of the fluid from within outwardly he termed *exosmosis*.

Of Dutrochet, Dr. John Hutton Balfour, of Edinburgh, makes mention when treating of the temperature of plants. He thus expresses himself : " While the nutritive processes are going on in the plant, there is a certain amount of heat produced. This, however, is speedily carried away by evaporation and other causes, and it is not easily rendered evident. Dutrochet, by means of Becquerel's thermo-electric needle, showed an evolution of heat in plants. In doing this, he prevented evaporation by putting the plant in a moist atmosphere. In these circumstances the temperature of the active vegetating parts, the roots, the leaves, and the young shoots, indicated a temperature above the air of $\frac{1}{2}$ to $\frac{3}{4}$ of a degree Fahrenheit. Van Beek and Bergsma, in their experiments on the *Hyacinthus Orientalis* and the *Entelea Arborescens*, found the proper heat of the active parts of plants about 1·8° F. above that of the air. The vital or proper heat of plants, according to Dutrochet, is found chiefly in the green plants, and it undergoes a quotidian paroxysm, reaching the maximum during the day, and the minimum during the night. When stems become hard and ligneous, they lose this vital heat. Large green cotyledons gave indications of a proper heat. The hour of quotidian maximum varied from 10 a.m. to 3 p.m. in different plants."

It is stated by Becquerel that in the act of vegetation, the earth acquires continually an excess of positive electricity, while the bark and part of the wood receive an excess of negative electricity. The leaves act like the green part of the parenchyma of the bark—that is to say, the sap which circulates in their tissues is negative with relation to the wood, to the pith, and to the earth, and positive with regard to the cambium. The electric effects observed in vegetables are due to chemico-vital action, and he asserts that the opposite electric states of vegetables and of the earth give reason to think that, from the enormous vegetation in certain parts of the globe, they must exert some influence on the electric phenomena of the atmosphere.

REFERENCES.—Gmelin's "Chemistry," Vol. I. p. 447; "Biog. Gén.," Vol. XV. p. 506; Poggendorff, "Annalen," Vol. I. p. 663; Larousse, "Dict. Univ.," Vol. VI. p. 1448; J. W. Ritter, in "Denkschr. d. Münch. Acad." for 1814, and the eighth ed. of the "Ency. Brit." Vol. XXI. p. 635, for observations concerning the *mimosa pudica* and the *mimosa sensitiva*; "Cat. Sc. Papers Roy. Soc.," Vol. II. pp. 422–425; Vol. VI. p. 646; Vol. VII. p. 584; Poggendorff, Vol. I. p. 633; "Observations on the diurnal variation of the magnetic needle," in Sturgeon's "Annals," Vol. VII. pp. 369–370, and in the *Comptes Rendus*, Vol. XII. p. 298, of Feb. 8, 1841; Burnet, "On the motion of sap in plants. Researches of Dutrochet on Endosmose and Exosmose . . ." London, 1829 ("Phil. Mag. or Annals," Vol. V. p. 389).

A.D. 1820.—Fresnel (Augustin Jean) (1788–1827), one of the most distinguished French mathematicians and natural philosophers, communicates a paper detailing his experiments for decomposing water by means of a magnet. He produced a current in an electro-magnetic helix enclosing a bar-magnet covered with silk, and on plunging the ends of the wire in water he observed some very remarkable effects which are set forth in the *Annales de Chimie et de Phys.*, series 2, Vol. XV. p. 219.

REFERENCES.—"Eloge de Fresnel," by Arago, in his "Œuvres," Vol. I; Account of Fresnel's life in the "Biog. Univ.;" Whewell, "Hist. of Induc. Sci.," 1859, Vol. II. pp. 96, 102, 114–117; "Œuvres complètes d'Augustin Fresnel, publiées par les soins du Ministre de l'Instruction Publique," Paris, 1870, in three vols.

A.D. 1820.—Sir Richard Phillips (1778–1851), communicates, July 11, to the *Philosophical Magazine* (Vol. LVI. pp. 195–200) a very interesting paper entitled "Electricity and Galvanism Explained on the Mechanical Theory of Matter and Motion." After reviewing the then existing theories, he concludes by saying:

"Electricity is no exception to the mechanical principles of matter and motion, and in regard to the kindred phenomena of galvanism, I will content myself with observing that it is merely *accelerated electricity*, the interposing fluid being palpably decomposed and evolving the electrical powers, each term in the series of plates being a new impulse or power added to the previous one, till the ultimate effect is accelerated, like that of a body falling by the continuous impulses of the earth's motions, or like a nail heated red-hot by accelerations of atomic motion produced by repeated percussions of a hammer."

Consult "Bibl. Ital.," Vol. XXVII. p. 107 for references to the "Annals of Philosophy," in which he mentions an experiment upon a young poplar, "whereby it would seem that copper was imbibed in the branches, etc., from a solution placed at its roots, and that it was precipitated on a knife used to cut off a branch."

A.D. 1820.—Brewster (Sir David) (1781–1868), a very dis-

tinguished English natural philosopher and writer, who had just founded the "Edinburgh Philosophical Journal" in conjunction with Prof. Robert Jameson, announces his discovery of the existence of two poles of greatest cold on opposite sides of the northern pole of the earth. By this he was, like other authors, led to the belief that there might be some connection between the magnetic poles and those of maximum cold, and he remarks (Noad "Manual," London, 1859, p. 545, and article "Magnetism" in "Encycl. Brit."): "Imperfect as the analogy is between the isothermal and magnetic centres, it is yet too important to be passed over without notice. Their local coincidence is sufficiently remarkable, and it would be to overstep the limits of philosophical caution to maintain that they have no other connection but that of accidental locality; and if we had as many measures of the mean temperature as we have of the variation of the needle, we might determine whether the isothermal poles were fixed or movable." Similar opinions entertained by Dr. Dalton, Dr. Traill and Mr. Christie are also mentioned by Noad, who quotes from Oersted's treatise on "Thermo-Electricity" the statement of the Danish philosopher "that the most efficacious excitation of electricity upon the earth appears to be produced by the sun, causing daily evaporation, deoxidation and heat, all of which excite electrical currents."

From his able paper in the *Edinburgh Philosophical Transactions* for 1820, one is led to share Sir David Brewster's belief "that two meridians of greatest heat and two of greatest cold are called into play, and that the magnetism of our globe depends in great measure upon electro or rather thermo-magnetic currents." The electromagnetic hypothesis was, he says, ably supported by Prof. Barlow in his paper "On the probable electric origin of all the phenomena of terrestrial magnetism," communicated to the *Phil. Trans.* for 1831. Brewster thus locates the two poles of maximum cold: The American pole in N. Lat. 73, and W. Long. 100 from Greenwich, a little to the East of Cape Walker; the Asiatic pole in N. Lat. 73 and E. Long. 80, between Siberia and Cape Matzol, on the Gulf of Oby. Hence the two warm meridians will be in W. Long. 10 and E. Long. 170, and the two cold meridians in W. Long. 100 and E. Long. 80.

As has already been indicated (under A.D. 1717, Leméry), Sir David Brewster was the discoverer of the pyro-electrical condition of the diamond, the garnet, the amethyst, etc. His development of some of Haüy's experiments led to a similar discovery, attaching to several mineral salts as well as to the plates and powders of the tourmaline, of the scolezite and the melozite; and he likewise experimented with the boracite, mesotype and with the several

minerals and artificial crystals detailed at pp. 208–215, Vol. I of the *Edin. Jour. of Science*, London, 1826; and in Chap. II. s. 1, vol. viii of the eighth " Encycl. Brit.," article on " Electricity."

At Part I. chap. i. s. 6 of the last-named article will be found Brewster's observations on the nature and origin of electrical light, his latest researches having been made, like those of Joseph von Fraunhofer (see A.D. 1814–1815), on the dark and on the luminous lines which appear in the spectrum formed from it by a prism.

During the year 1831 appeared Brewster's " Treatise on Optics," his " Life of Sir Isaac Newton," and his " Letters on Natural Magic." It is in one of the chapters of the last-named work that he treats of automatic talking machines and remarks: " We have no doubt that before another century is completed a talking and a singing machine will be numbered among the conquests of science."

Brewster's other scientific treatises are too numerous and cover too wide a range to be enumerated here. The " Catal. of Sci. Papers of the Roy. Soc." (Vol. I. pp. 612–623) gives the titles of as many as 299 contributions made by him on important subjects, and he has had no less than 76 papers in the first 39 parts of the *North British Review*, 30 in the *Phil. Trans.* and 28 in the *Edin. Review*. They appear, in fact, in all the prominent publications of his time, and have won for him leading honours, more especially from the Edinburgh and Aberdeen Universities and the Scotch, Irish, English and French Societies, the French Academy of Sciences doing him the signal honour of selecting him as one of its eight foreign associates in place of Berzelius, deceased. Conjointly with Davy, Herschel and Charles Babbage, he originated the British Association during 1831, and it was in this same year that he was knighted and decorated by King William IV. He had been made a Fellow of the Royal Society of Edinburgh in 1808, and had during the same year undertaken the editorship of the " Edinburgh Encyclopædia of Sci., Lit. and Art." This he continued for twenty-two years, after which he edited the *Edin. Jour. of Sci.*, and also entered with Taylor and Phillips upon the editorship of the *London and Edin. Phil. Mag. and Journal*. Many of our readers will doubtless be glad to know that the last named was a continuation of the well-known *Philosophical Magazine* so often quoted in this " Bibliographical History."

REFERENCES.—The obituary notice contributed by Dr. J. H. Gladstone to the proceedings of the Royal Society; *Chemical News*, Amer. reprint, Vol. II. pp. 198, 233; also p. 293 for accounts given by Sir J. Simpson and Prof. Fraser; J. Robison and Brewster, " A System of Mechan. Phil.," London and Edin., 1822; Ferguson and Brewster's " Essays and Treatises on Astr. Elect.," etc., Edinburgh, 1823; Brewster's several articles in the " Encycl. Britannica," 7th and 8th editions, on

"Electricity and Magnetism"; *Transactions of the Roy. Soc. of Edinburgh*, Vols. IX. 1821; XX. Part IV; *Edin. Jour. of Sci.*, Oct. 1824, No. 2, p. 213; Noad, "Manual," London, 1859, pp. 31, 32, 636–638; Harris, "Magnetism," Part III. p. 119; Whewell, "Hist. of Induc. Sci.," 1859, Vol. II. pp. 75, 81, 331, 332; the lectures delivered by Wm. A. Miller during 1867 before the Royal Institution of Great Britain.

Charles Babbage (1792–1871), a prominent English scientist who is mentioned above and who besides being one of the founders of the Royal Astronomical Society, as has already been stated, was also a founder of the British Association and the originator of the Statistical Society, is the author of valuable papers, exhibiting a wide range of learning and research—mainly on mathematical subjects and relating to magnetical and electrical phenomena—which have been published in the Reports of the Royal and other Societies ("English Cycl.," Vol. I. p. 457; "Encyl. Brit.," ninth ed., Vol. III. p. 178; Larousse, "Dict.," Vol. II. pp. 5–6; account of Babbage's work in C. R. Weld's "Hist. Roy. Soc.," Vol. II. pp. 369–391).

A.D. 1820.—Fisher (George) (1794–1873), who two years before had joined Captain David Buchan in his voyage to the Arctic regions, is the first to point out the true cause of the sudden alteration in the rates of chronometers at sea. "He observed," says Dr. Roget, "that the chronometers on board the 'Dorothea' and 'Trent' had a different rate of going from that they had on shore, even when these vessels had been frozen in, and therefore when their motion could not have contributed to that variation; . . . this effect could be attributed only to the magnetic action exerted by the iron in the ships upon the inner rim of the balance of the chronometers, which is made of steel. A similar influence was perceptible on placing magnets in the neighbourhood of the chronometers. This conclusion was confirmed by experiments made for this purpose by Mr. Barlow, who ascertained that masses of iron devoid of all permanent magnetism occasioned an alteration in the rates of chronometers placed in different positions in their vicinity."

References.—Fisher's article "On the Errors in Longitude as Determined by Chronometers at Sea, Arising from the Action of the Iron in the Ships upon the Chronometers," communicated by John Barrow, F.R.S., to the *Phil. Mag.*, Vol. LVII. pp. 249–257. See besides, *Edinburgh Jour. Sci.*, London, 1826, Vol. V. p. 224; *Phil. Trans.* for 1820, Part. II. p. 196, and the volume for 1833, relative to magnetical experiments; also the "Lib. U. K." (Magn.), p. 63. For Capt. Buchan, consult Barrow's "Chronological History of Voyages into the Arctic Regions."

Mr. George Thomas Fischer (1722–1848) is the author of "A Practical Treatise on Medical Electricity" (Poggendorff, Vol. I. p. 756).

A.D. 1820.—Bonnycastle (Charles), Professor of Mathematics in the University of Virginia, treats of the distribution of the magnetic fluids in masses of iron, as well as of the deviations which they produce in compasses placed within their influence, at pp. 446–456, Vol. LV of Tilloch's *Philosophical Magazine.*

He refers to the then recent publication of Peter Barlow's "Essay on Magnetic Attractions," containing the results of many experiments, made principally upon spheres of iron, as well as to Dr. Young's views of the subject, which were printed by order of the Board of Longitude, and he says that the principle upon which he intends establishing his inquiry "is an extension of the law that regulates the action of electrified bodies upon conductors; which was first given by M. Poisson in the Memoirs of the Institute for 1811, and employed by him to determine the development of the electric fluids in spheres that mutually act on each other."

The aforenamed dissertation, at the time, called forth a rejoinder from a correspondent and a further communication from Mr. Bonnycastle, both of which appear at pp. 346–350, Vol. LVI of the same publication.

References.—Silliman's *Journal,* Vol. XL. p. 32; "Sketch of the Life of Chas. Bonnycastle," by Thomas Thomson; Poggendorff, Vol. I. pp. 234, 235; article "Magnetism," p. 9, Vol. XIV of the eighth "Britannica."

A.D. 1820.—Harris (Wm. Snow), member of the College of Surgeons, and a very distinguished English scientist (1791–1867), proposes to the Board of the Admiralty his system of lightning conductors, of which an account appears at p. 231, Vol. LX of the *Phil. Mag.*, as well as in a separate work published at London during 1822. This is followed by his "Observations on the Effects of Lightning . . ." 1823, and by papers relative to the defence of ships and buildings from lightning, which were published, more particularly, in several numbers of the *Nautical Magazine*, the *Phil. Mag.*, the *Annals of Electricity*, and in the *Proc. Lond. Elec. Soc.* for 1842, as well as in his "Record of Phil. Papers," and under separate heads during many years between 1827 and 1854. One of his biographers remarks:

"His researches have gone far to remove certain popular errors as to what have been called 'conductors' and 'non-conductors' of electricity, and to show the inutility of the old form of lightning rod in the majority of cases; it being necessary, in place of such rod form, to link into one great chain all the metallic bodies employed in the construction of a building, thus providing a connection with these conductors between the highest parts and the ground, the single conductor, in one highest part, being possibly insufficient

to divert the course of the fluid and protect the whole fabric. These general principles have been largely applied to the protection of the ships of the Royal Navy during the last five and twenty years, under his advice and direction; and, laying aside the opinions which had been commonly received, the masts themselves of a ship have all been rendered perfectly conducting by incorporating with the spars capacious plates of copper, whilst all the large metallic masses in the hull have been tied, as it were, into a general conducting chain, communicating with the great conducting channels in the masts, and with the sea. This may be considered as the greatest experiment ever made by any country in the employment of metallic conductors for ships, and the result has been to secure the navy from a destructive agent, and to throw new light upon an interesting department of science" (Whewell, "Hist. of Induc. Sci.," Vol. II. pp. 199, 200; *Phil. Mag.* for March 1841; eighth "Encycl. Britannica," Vols. VIII. pp. 535, 610, 611, and XX. p. 24; "Edin. Review" for Oct. 1844, Vol. LXXX. pp. 444–473).

Harris was the first, says Brewster, who introduced accurate quantitative measures into the investigation of the laws of statical electricity—the unit measure by which quantity is minutely estimated—and also the hydro-electrometer and scale-beam balance by which its intensity and the laws of attractive forces at all distances are demonstrated. Of not less value is the thermo-electrometer, by which the heating effects of given quantities of electricity are measured and rendered comparable with the varying conditions of quantity and intensity. Besides these instruments, we owe to Harris the discovery of a new reactive force, through which repulsion and other small physical forces are investigated and determined by means of his bifilar balance, founded upon the reactive force of two vertically suspended parallel threads when twined upon each other at a given angle, and acted upon by a suspended weight. With the aid of these instruments he has carried on a variety of important inquiries into the laws of electrical forces, and the laws and operations of electrical accumulation (eighth "Brit.," Vol. VIII. p. 535). His papers on the subject appeared in 1825 and 1828, and a *résumé* of them is given by Noad ("Manual," 1859, pp. 35, 137–140), as well as in the "Electricity" article of the "Britannica," both of which contain descriptions and illustrations of Harris' unit jar and electro-thermometer.

During the year 1827 Mr. Harris published in the *Trans. Roy. Soc. of Edinburgh* his memoir entitled "Experimental Inquiries Concerning the Laws of Magnetic Forces," which experiments were made by means of a new and very accurate apparatus invented by him for examining the phenomena of induced magnetism. The

above was followed by two other memoirs, published in the *Phil. Trans.* for 1831, " On the Influence of Screens in Arresting the Progress of Magnetic Action . . ." and " On the Power of Masses of Iron to Control the Attractive Force of a Magnet," which are discoursed of in the " Britannica " article on " Magnetism," wherein special treatment is also given more particularly to Mr. Harris' researches concerning artificial magnets as well as the magnetic charge, the development of magnetism by rotation and the phenomena of periodical variations (" Rudim. Mag.," Part III. p. 60; Fahie's " Hist. of Elec. Tel.," pp. 283, 284).

Besides additional apparatus named in the subjoined references Mr. Harris invented a very effective steering compass, of which an account is given in Part III. pp. 148–153, of his " Rudimentary Magnetism," as well as at p. 594 of Noad's " Manual," at p. 105 of the " English Cyclopædia " (Arts and Sciences), Vol. III, and at p. 80, Vol. VIII, 1857, " Encycl. Britannica," and he has also devised a magnetometer for the measurement of electric forces, of which the description and illustrations appear in the last-named publication as transcribed from Mr. Harris' work already mentioned.

Mr. Harris was made a F.R.S. in 1831, and received the Copley medal four years later. It was in 1843 he published his well-known work " On the Nature of Thunderstorms," the plans he advocated being adopted in 1847, when he received the order of knighthood as well as a large money grant from the English Government in acknowledgment of his scientific services. The following appears in the obituary notice of Sir Wm. Snow Harris, contributed by Mr. Charles Tomlinson to the *Proceedings of the Roy. Soc.* (XVI, 1868) :

" Harris' sympathies were with the Bennetts, the Cavendishes, the Singers, the Voltas of a past age. Frictional electricity was his *forte* and the source of his triumphs. He was bewildered and dazzled by the electrical development of the present day, and almost shut his eyes to it. He was attached too closely and exclusively to the old school of science to recognize the broad and sweeping advance of the new. He was not conscious even of being behind his age when he presented to the Royal Society in 1861 an elaborate paper on an improved form of Bennett's discharger, and still less in 1864, when he discussed the laws of electrical distribution, and yet relied upon the Leyden jar and the unit jar."

REFERENCES.—*Trans. of the Plymouth Institution*, also *Trans. of the Roy. Soc.* for 1834, 1836, 1839; " Eng. Encycl." (" Common Electricity "), Vol. III. p. 801; W. A. Miller, " Elem. of Chem.," 1864, p. 32. For descriptions of his bifilar balance see the eighth " Britannica," Vol. VIII. p. 623; Harris, " Rud. Elec.," p. 99, and " Rud. Magn.," pp. 119, 120; Noad, " Manual," pp. 26, 27, 37, 40, 41, 63, 580; C. Stahelin, " Die Lehre . . ." 1852; P. Volpicelli, " Ricerche analitiche . . ." Roma,

1865, while, for his balance electroscope and electrometers, see "Edin. Phil. Trans.," Dec. 1831; eighth "Britannica," Vol. VIII. pp. 540, 590, 620 622, 624; Harris, "Rud. Elec.," pp. 99, etc.; the "Bakerian Lecture"; the "Report of British Association," Dundee, 1867, for an able account of electrometers by Sir William Thomson. His electrical machine is described at pp. 74–76 of Noad's "Manual," as well as at p. 604, Vol. VIII of the 8th "Britannica," the latter also giving, at p. 550, Harris' experiments on the electrical attraction of spheres and planes. "Catal. Sc. Papers Roy. Soc.," Vol. III. pp. 191–192; Lippincott's "Biog. Dict.," 1886, p. 1230; Biography in Harris' "Frictional Electricity"; "Abstracts of Papers . . . Phil. Trans., 1800–1830," Vol. II. p. 298; *Lumière Electrique* for Oct. 3, 1891, p. 49; reprint of Sir Wm. Thomson's "Mathematical Papers," 1872; "Brit. Asso. Reports" for 1832, 1835, 1836; *Edin. Phil. Trans.* for 1834; Fahie's "History," p. 321; *Edin. and London and Edin. Phil. Mag.* for 1840; *Phil. Trans.*, 1842; *Phil. Mag.* for 1856–1857, and Harris' "Manuals of Electricity, Galvanism and Magnetism," published in John Weale's Rudimentary Series.

A.D. 1820.—Mitscherlich (Eilardt—Eilhert), Professor of Chemistry at the Berlin University, discovers what is called *Isomorphism* (*isos*, equal; *morphe*, form), showing that bodies containing very different electro-positive elements could not well be distinguished from each other; it was impossible therefore to put them in distant portions of the classification, and thus, remarks Whewell, the first system of Berzelius crumbled to pieces.

In other words, Mitscherlich was the first to draw attention to the fact that two bodies having the same composition could assume different forms; to this law Berzelius gave the name of *Isomerism* (*isos*, equal; *meros*, part).

Sir John Herschel makes particular mention ("Treatise on Light," s. 1, 113) of Mitscherlich's remarkable experiment with sulphate of lime—the alteration in the tints of which by heat, it is said, was first observed by Fresnel. This experiment was repeated by Sir David Brewster, and he discovered still more curious properties in *glauberite*, all of which are detailed in Vol. I. p. 417 of the *London and Edinburgh Phil. Mag.* for Dec. 1832.

References.—"Cat. Sci. Papers Roy. Soc.," Vol. IV. pp. 413–416; "Library Useful Knowledge" (Pol. of Light), p. 63; Poggendorff, Vol. II. pp. 160, 161; the very able treatise of Mr. J. Beete Jukes on "Mineralogical Science"; also Poggendorff's *Annalen*, Vol. XV. p. 630, for Mitscherlich on the chemical origin of iron glance in volcanic masses.

A.D. 1820.—Ampère (André Marie) (1775–1836), one of the most distinguished philosophers of the century, Professor of Mathematical Analysis in the French Ecole Polytechnique (1809), afterwards Professor of Physics at the Collège de France, reads before the Académie Royale des Sciences, Sept. 18, 25, Oct. 9, 13, and Nov. 6, 1820, papers

containing a complete exposition of the phenomena of electro-dynamics. His investigations were subsequently embodied in the "Recueil d'Observations . . ." Paris, 1822, and were still further developed during 1824 and 1826, as shown through both his "Précis de la théorie . . ." and "Théorie des Phénomènes Electro-Dynamiques."

The news of Oersted's discovery of the relation existing between the electric current and the magnet—the fundamental fact of electro-magnetism—was made known in July 1820, and the inquiry was at once taken up more particularly by Ampère, Arago, Biot, and Félix Savary in France, as well as by Berzelius, Davy, De la Rive, Cumming, Faraday, Joseph Henry, Schweigger, Seebeck, Sturgeon, Nobili and others throughout Europe and elsewhere. Of all these scientists, Ampère proved the most energetic, and, within three months of the announcement of Oersted's discovery, his first memoir on the subject was publicly read in Paris.

In this first paper, Sept. 18, he explains the law determining the position of the magnetic needle in relation to the electric current, and he also makes known his intended experiments with spiral or helical wires, which he predicts will acquire and retain the properties of magnets so long as the electrical current flows through them. He likewise explains his theory of magnets, saying that if we assume a magnet to consist of an assemblage of minute currents of electricity whirling all with the same direction of rotation around the steel molecules and in planes at right angles to the axis of the bar, we will have an hypothesis which will account for all the known properties of a magnet. He constructed his spirals and helices, and to the astonishment of all, he produced magnets formed only of spools of copper wire traversed by electric currents. We can readily imagine, adds Prof. A. M. Mayer, the intense interest awakened by this discovery, a discovery which caused Arago to exclaim, "What would Newton, Halley, Dufay, Æpinus, Franklin and Coulomb have said if one had told them that the day would come when a navigator would be able to lay the course of his vessel without a magnetic needle and solely by means of electric currents?" "The vast field of physical science," says Arago, "perhaps never presented so brilliant a discovery, conceived, verified and completed with such rapidity." Thus Ampère became the author of a beautiful generalization, which not only included the phenomena exhibited by the new combinations of Oersted, but also disclosed forces existing in arrangements already familiar, although they were never detected till it was thus pointed out how they were to be looked for. His electro-dynamic theory of the action of currents and of magnets has been thought worthy of a place near the Principia of Newton . . . it deservedly gained for

him the title of the Newton of electro-dynamics, as he did for this branch of science even more than Coulomb had previously done for electro-statics (Profs. A. M. Mayer and W. B. Rogers, "Memorial of Jos. Henry," 1880, pp. 81, 476; Lardner, "Lectures," 1859, Vol. II. p. 120; Fahie, "Hist. Tel.," p. 276).

The experiments of Oersted and Ampère were at once greatly extended by many scientists, among whom may be especially mentioned MM. Yelin, Bœckmann, Van Beek, De la Rive, Moll, Nobili, Barlow and Cumming. The last named apparently gave the earliest notice of the increased effects of a convolution of wire around the magnetic needle, and constructed the first astatic needle galvanometer (*Trans. Camb. Soc.*, Vol. I. p. 279). The Chevalier Julius Konrad Yelin (1771–1826), German mathematician, ascertained that the electricity of an ordinary machine when passed along a helix, either in simple electrical sparks or by discharges from a battery, has the effect of rendering an included needle magnetic. According to Dr. Henry, M. Bœckmann found in varying these experiments that no modification of the effect is produced by altering the diameter of the helix from half an inch to thirteen inches. With a helix of thirty-four inches diameter, and a coated surface of 300 square inches, much less magnetism was, however, imparted; and with one of eighty-four inches it was scarcely perceptible. It was found that a needle outside of the helix was magnetized as much as one within; that after being once fully magnetized a continuation of the discharges diminished its power; and that five jars, each of 300 square inches, did not produce, by repeated discharges, much more effect than one of them (Poggendorff, Vol. II. p. 1382; Gilbert's *Annalen* for 1820–1823).

In his second paper, Sept. 25 (*Ann. de Chim. et de Phys.*, Vol. XV. pp. 59–170), Ampère makes known the results of his experiments on the mutual attractions and repulsions of electrical currents, showing conclusively that when the voltaic current is passed in the same direction through two parallel wires, so placed as to move freely, they attract each other, and that they are repelled if the currents are passed in opposite directions. Thus he establishes the second fundamental law of electro-magnetism, the first law, instituted as we have seen by Oersted, being that the magnetical effect of the electrical current is a circular motion around the current. In the last-named paper he also proposes the hypothesis of currents of electricity circulating from east to west around the terrestrial globe in planes at right angles to the direction of the dipping needle, to account for the phenomena of terrestrial magnetism (Roget, "Electro-Magn.," p. 47).

In his third paper, Oct. 9, Ampère investigates the properties

of currents transmitted through wires forming closed curves (*courbes fermées*) or complete geometrical figures, an inquiry also alluded to in another memoir read Oct. 30, 1820.

These papers were immediately followed by others, which engaged nearly all the sittings of the Academy between Dec. 4, 1820, and Jan. 15, 1821. In these he brings forth new confirmations of his theories, and reduces the phenomena of electro-magnetism to mathematical analysis.

Mr. Samuel Prime remarks ("Life of Morse," 1875, p. 266) that the discovery of the action of the spiral coil upon the magnetic needle seems to have been independently made by Ampère in 1821:

"I showed that the current which is in the pile acts on the magnetic needle by the conjunctive wire. I described the instrument, which I proposed to construct, and, among others, the galvanic spiral. I read a note upon the electro-chemical effects of a spiral of iron wire, subjected to the action of the earth, directing an electric current as well as a magnet. I announced the new fact of the attraction and repulsion of two electric currents, without the intermediation of any magnet, a fact which I had observed in conductors twisted spirally (Tilloch's *Journal of Science*, Vol. LVII. p. 47, 1821).

One of his biographers, Professor Chrystal says: "Scarcely had the news of Oersted's discovery reached France, when a French philosopher, Ampère, set to work to develop the important consequences which it involved. Physicists had long been looking for the connection between magnetism and electricity, and had, perhaps, inclined to the view that electricity was somehow to be explained as a magnetic phenomenon. It was, in fact, under the influence of such ideas, that Oersted was led to his discovery. Ampère showed that the explanation was to be found in an opposite direction. He discovered the ponderomotive action of one electric current on another, and, by a series of well-chosen experiments, he established the elementary laws of electro-dynamic action, starting from which, by a brilliant train of mathematical analysis, he not only evolved the complete explanation of all the electro-magnetic phenomena observed before him, but predicted many hitherto unknown. The results of his researches may be summarized in the statement that an electric current, in a linear circuit of any form, is equivalent in its action, whether on magnets or other circuits, to a magnetic shell bounded by the circuit, whose strength at every point is constant and proportional to the strength of the current. By his beautiful theory of molecular currents, he gave a theoretical explanation of that connection between electricity and magnetism which had been the dream of previous investigators. *If we except the discovery of the*

laws of the induction of electric currents, made about ten years later by Faraday, *no advance in the science of electricity can compare for completeness and brilliancy with the work of Ampère.* Our admiration is equally great, whether we contemplate the clearness and power of his mathematical investigations, the aptness and skill of his experiments, or the wonderful rapidity with which he elucidated his discovery when he had once found the clew."

"Oersted," remarks M. Babinet, "was the Christopher Columbus of magnetism; Ampère became its Pizarro and its Fernand Cortez."

Of Ampère's *astatic* needles, a description, taken from one of his memoirs (*Ann. de Ch. et de Ph.,* Vol. XVIII. p. 320), appears at pp. 280–281 of Fahie's "History" (Knight's "Mech. Dict.," 1874, Vol. I. p. 171, and Vol. II. p. 1181). For this greatly perfected form of galvanometer the credit has erroneously been given to Prof. Cumming, who first suggested the idea of neutralizing the directive force of the needle arising from the earth's magnetism, which he did by placing a magnetized needle immediately beneath the movable or index needle. Fahie adds, in a footnote: "In Prof. Cumming's paper 'On the Connection of Galvanism and Magnetism,' read before the Cambridge Philosophical Society, April 2, 1821, he described a near approach to the astatic needle. In order to neutralize the terrestrial magnetism he placed a small magnetized needle under the galvanometer needle" (*Trans. Cam. Phil. Soc.,* Vol. I. p. 279). The credit of Ampère's discovery is sometimes given to Nobili, as in Noad's "Manual of Electricity," London, 1859, p. 327; also Roget's "Electro-Magnetism" in "Library of Useful Knowledge," London, 1832, p. 42.

As has been already shown (Laplace, A.D. 1820), the first proposal to apply Oersted's discovery to telegraphic purposes by substituting the deflection of the magnetic needle through electric currents for the divergence of the pith balls of the electroscope, was made by Ampère, in his Memoir of Oct. 2, 1820, which appears in the *Comptes Rendus,* and at p. 72, Vol. XV of the *Annales de Chimie et de Physique.* His plan, remarks Sabine, was, however, doomed to the same fate as that of Sömmering, of never coming into practice, and for the same reasons, principally the number of line wires. Had Ampère combined his system, or rather the one of Laplace, with that which Schweigger proposed of reducing Sömmering's telegraph to two wires, or with any other using a code of signals, the problem of the electric telegraph would have been solved from the year 1820. Ampère makes no mention of surrounding the needles with *coils of wire,* as is so frequently stated by writers on the telegraph. Indeed he could not then have even heard of the galvanometer; for, although

Schweigger's paper on the subject was read at Halle on the 16th of September 1820, it was not published until the November following.

M. Jean Jacques Antoine Ampère (1800–1864), son of André Marie Ampère, was an accomplished scholar who succeeded François Andrieux as professor at the Collège de France and became a member of the French Academy in 1847.

References.—For accounts of Ampère's rotary magnet, electro-dynamic cylinders, revolving battery, and of his electripeter employed to alter rapidly the direction of the electric current in voltaic batteries, consult pp. 639, 640, 643, Vol. VIII of the eighth "Britannica." Fahie, "Hist, of El. Tel.," p. 303. See "Catal. Sci. Papers Roy. Soc.," Vol. I. pp. 58, 61; Messrs. Sainte-Beuve et Littré's account of his life and labours in the *Revue des Deux Mondes* for Feb. 15, 1837; "Notice sur M. Ampère," *par* M. E. Littré, Paris, 1843; Arago's "Eulogy on Ampère," translated, at pp. 111–171 of the "Report of the Smithsonian Institution" for 1872. Consult also "Report Smiths. Instit." for 1857, pp. 100–107; Ampère's biography in the *Sci. Am. Suppl.*, No. 674, p. 10760; also Ampère's "Journal et Correspondance," Poggendorff, Vol. I. pp. 39, 40; Address of His Royal Highness the Duke of Sussex to the Eng. Roy. Soc., 1836; Barlow on "Magnetic Attractions": *Comptes Rendus* for 1838, Vol. VII. p. 81; *Bibl. Univ.*, XX; *Phil. Mag.*, Vols. LVI. p. 308; LVII. pp. 40–47, "On the Electro-Magnetic Experiments of Oersted and Ampère," by Mr. Hatchett, and pp. 47–49; *Ann. de Phys. de Bruxelles*, Vol. VII; *Ann. de Ch. et de Phys.*, XXIX; Du Moncel, Vol. III. p. 7; "Acad. de Paris," Sept. 12, 1825; *La Lum. Elect.* for Oct. 31, 1891, p. 202; Roch, in "Zeitschr. f. Mathém," 1859, p. 295; Roget on Ampère's theory of Mag.; K. W. Knochenhauer, *Pogg. Annal.*, XXXIV. p. 481; J. Marsh, "On a Particular Construction of M. Ampère's Rotating Cylinder," *Phil. Mag.*, LIX. p. 433, 1822; Henn, "De Amperi principiis . . ."; "Memorial of Joseph Henry," 1880, pp. 59, 81; "Lib. of Use. Know." (El. Mag.), pp. 24, 28, 83–92; Harris, "Rud. Elec.," pp. 170, 171, and "Rud. Mag.," p. 130; Noad, "Manual," pp. 661–662, 861–864; "Encyl. Metrop." (El. Mag.), Vol. IV. pp. 5–8; Highton, "Elec. Teleg.," p. 39; Gmelin's "Chemistry," Vol. I. p. 317; Mrs. Somerville, "Conn. Phys. Sci.," 1846, pp. 320, 321; Dr. Lardner, "Lectures," Vol. II. p. 125; J. F. W. Herschel, "Prelim. Dis. Nat. Phil.," 1855, p. 243; Whewell, "Hist. Induc. Sc.," 1859, Vol. II. pp. 242, 246, 619; "Ann. of Sc. Disc." for 1850, p. 129, and for 1865, p. 125; "Smithsonian Report" for 1878, p. 273; Sturgeon, "Sci. Researches," Bury, 1850, pp. 12, 16, 29; *Jour. Frankl. Inst.* for 1851, Vol. XXII. p. 59; Turnbull, "El. Mag. Tel.," 1853, pp. 55 and 221; (Vail's "History," pp. 133, 134; Prof. Henry's Evid., 85a, record; Doct. Channing's Ev., 47a, record; Hibbard, Ev., 31*a*. . . .) See also Humboldt's "Cosmos," articles "Aurora Borealis," "Volcanoes," "Earthquakes"; Ampère et Babinet, "Exposé des Nouv. Déc. . . de Oersted, Arago, Ampère, Davy, Biot, Erman, Schweigger, De la Rive," etc., Paris, 1822, translated into German "Darstellung der neuen . . dem Französischen," Leipzig, 1822, and alluded to in *Lumière Electrique* for July 18, 1891, pp. 148, 149; Hachette et Ampère, "Sur les Expériences de Oersted et Ampère": *Journal de Physique* for September 1820. *Annales de Chimie* for 1825; "Journal des Savants," for June 1872; "Dict. Génér. de Biogr. et d'Histoire," Paris, 2e ed., pp. 85–86; "Collection de Mémoires relatifs à la Physique," Paris 1885, 1887, Vols. II and III *passim*, as per indexes; "Amer. Journ. of Psychology," Vol. IV. pp. 6–7.

For William Ritchie (1790–1837), the author of an able paper, "On electro-magnetism, and Ampère's proposal of telegraphic com-

munication by means of this power," consult *Phil. Trans.* for 1833, p. 313; "Abstracts of Papers . . . Roy. Soc.," Vol. II. pp. 350, 382; *Phil. Mag.* or *Annals*, Vol. VII, 1830, p. 212; *Phil. Mag. and Journal of Science*, Vol. III, 1833, pp. 37, 122, 124, 145.

For Leopoldo Nobili (1784–1835), frequently mentioned above, consult "Bibl. Univ.," Bruxelles, 1834 (Sc. et Arts), Tome LVI. pp. 82–89, 150–168; "Edin. Trans." Vol. XII and *Phil. Mag.* Vol. XI, 1832, p. 359, for the account of experiments made by James David Forbes, similar to those of Nobili, wherein an electric spark was elicited from a natural magnet. For J. D. Forbes, see also *Phil. Mag.*, 1832, Vol. XI. p. 359. For Nobili and Antinori, consult *Phil. Mag.*, Vol. XI, 1832, pp. 401, 466; "Bibl. Britan.," Vol. XXV, 1824, N.S. p. 38; Vol. XXIX, 1825, N.S. p. 119. For Antinori and Marchese Cosimo Ridolfi, consult "Bibl. Britan." Vol. XVI, N.S., 1821, pp. 72-75, 101–118.

For Prof. James Cumming (1777–1861), also frequently named in above article, consult *Phil. Mag.*, Vol. LX, 1822, p. 253; "Bibl. Britan.," Vol. XXV, N.S., 1824, p. 104, for experiments of Cumming, Trail and Marsh; the investigations in the same line of Mr. Thos. Stuart being especially reported on in "Bibl. Britan.," Vol. XXVII, N.S., 1824, pp. 199–206; "Dict. of Nat. Biog.," Vol XIII. p. 296; "Edin. Phil. Journal," 1824, Vol. X. p. 185; "Cat. Sc. Papers Roy. Soc.," Vol I. pp. 58–61; Vol. VI. p. 565; Vol. VII. p. 29; "Bibl. Britan.," Vol. XVI, N.S. p. 309; Vol. XVII, N.S. p. 16; Vol. XIX. p. 244; Vol. XX. pp. 173, 258; Vol. XXIV. p. 109.

For Le Chevalier Julius Konrad von Yelin (1771–1826), consult "Bibl. Britan.," Vol. XXIII, N.S., 1823, p. 38; Vol. XXIV, N.S., 1823, p. 253, and, especially, the important tract on the discovery of thermo-magnetism at p. 31 of his "Die Akademie der Wissenschaften und ihre Gegner," Munich, 1822.

A.D. 1820.—Arago (Dominique François Jean), famous French astronomer, physicist and statesman (1786–1853), who at the early age of twenty-three had, besides being Assistant Astronomer to the Observatory, become the successor both of Lalande in the Academy of Sciences and of Monge in the chair of analytical mathematics at the Polytechnic School, and who, conjointly with Gay-Lussac, had founded the highly valued *Annales de Chimie et de Physique* in 1816, communicates to the French Institute, on the 25th of September 1820, his discovery that the electric current has the power of developing magnetism in iron and steel. Into the axis of a galvanic conductor made in the form of a coil, or helix, he placed a needle, the extremities of the wire coil being connected to the poles of a battery, and with this he proved that the wire not only acted on bodies already

magnetized, but that it could develop magnetism in such as did not already possess the power. When soft iron was used, the magnetism given was only temporary, but on repeating the experiment, M. Arago succeeded completely in permanently magnetizing small steel needles. Arago's paper on the subject appears at p. 94, Vol. XV of the *Ann. de Ch. et de Ph.*, and it is said that at about the same time Dr. Thos. J. Seebeck (1770–1831), and Georg Friedrich Pohl (1788–1849) laid similar results before the Berlin Academy, also that Sir Humphry Davy independently made a like discovery, of which he advised Dr. Wollaston, Nov. 12, 1820. Reference to this fact has already been made at Davy, under date A.D. 1801, wherein it was stated that the latter had found iron filings to so adhere to the connecting wire as to form a mass ten or twelve times the thickness of the wire. This was also the case in the experiments of M. Arago, who, upon observing that the filings rose before coming in contact with the conjugate wire, drew the conclusion that each small piece of iron was converted into a temporary magnet. Thus was Arago led to the discovery of what is called magnetic induction by electric currents, or, in other words, that an electrical current passing through a conductor will induce magnetic action in such bodies near it as are capable of being magnetized (*Phil. Trans.* for 1821, p. 9; Tilloch's *Jour. of Sci.*, Vol. LVII. p. 42, 1821; eighth "Britannica," Vol. VIII. p. 532 and Vol. XIV. p. 640; Thomas Thomson, "Outline of the Sciences," p. 563).

A fact worth noting in connection with the development of Oersted's discovery by both Arago and Ampère, is that in order "to prevent the communication of the electricity laterally in the folds of the coil, the wire was insulated by varnish in the first instance and afterward by winding silk or cotton around it" (F. C. Bakewell, "Elec. Sci.," London, 1853, p. 37).

On the 22nd of November 1824, Arago announced to the French Academy of Sciences the remarkable discovery made by him of a new source of magnetism in rotatory motion. He was led to this by observing that when a magnetic needle was oscillating above or close by any body, such as water or a plate of metal, it gradually oscillated in arcs of less and less amplitude, as if it were standing in a resisting medium, and, besides, that the oscillations performed in a given time were the same in number (Humboldt's "Cosmos," "Magnetic Observations," 1825). He caused a circular copper plate to revolve immediately beneath a magnetic needle or magnet, freely suspended so that the latter might rotate in a plane parallel to that of the copper plate, and he found that the needle tends to follow the circumvolution of the plate; that it will deviate from its true direction, and that by increasing the velocity of the plate the

deviation will increase till the needle passes the opposite point, when it will continue to revolve, and at last with such rapidity that the eye will be unable to distinguish it. This, says Mrs. Somerville, is quite independent of the motion of the air, since it is the same if a pane of glass be interposed between the magnet and the copper. When the magnet and the plate are at rest, not the smallest effect, attractive, repulsive, or of any kind, can be perceived between them. In describing this phenomenon Arago states that it takes place not only with metals, but with all substances, although the intensity depends upon the kind of substance in motion.

Arago's experiments were repeated in London, March 7, 1825. His valuable discovery, which obtained for him the Copley medal, and which confirms the doctrine of the universal prevalence of magnetism in all bodies, is recorded in Arago's "Sur les Déviations . . . aiguille aimantée" (*An. de Ch. et de Ph.*, Vol. XXXIII, and *Phil. Trans.*, p. 467 for 1825), and a solution of the phenomena is given by Faraday in *Phil. Trans.* for 1832, p. 146, by Sir John Leslie in the Fifth Dissertation of the eighth "Britannica," p. 746, as well as in the article "Magnetism" of the latter publication, and in Mrs. Somerville's "Conn. of Phys. Sc.," pp. 325–327. (See also the observations recorded in Humboldt's "Cosmos," 1849, Vol. I. pp. 172, 173; in Dr. Thomson's "Outline of the Sciences," pp. 556–558; Fahie, pp. 282, 283, 321; Dr. Whewell, Vol. II. pp. 254–256; Brewster's *Edin. Jour. of Sci.*, 1826, Vol. III. p. 179; "Dict. Gén. de Biogr. et d'Histoire," Paris, 2^{e} ed. p. 126.)

In Brewster's *Edinburgh Journal of Science* (Vol. V. p. 325), notice is given of Arago's then recent researches on the influence which bodies considered not magnetic have on the motions of the magnetic needle, and reference is made to a new communication transmitted by Arago to the Académie des Sciences, as well as to a report of additional experiments in the same line given at meetings held July 3 and 10, 1826. Arago satisfactorily meets the denials made by Leopoldo Nobili and another Italian natural philosopher (Liberato Giovanni Bacelli) that substances not metallic have any influence on the magnetic oscillations, and he announces as a result of his investigations that, for certain positions of a vertical needle, and for velocities of rotation sufficiently rapid, the repulsive force which is exerted in the direction of the radius is as great as the force perpendicular to the radius, of which the effects are observed upon a horizontal needle.

Poisson having stated in his memoir "On the Theory of Magnetism" in motion (see Poisson at A.D. 1811) that Coulomb had recognized the magnetic virtue in all bodies, independently of the iron which they contain, Arago remarked that the idea

of Coulomb was quite different from his, Coulomb having been of opinion that a quantity of iron, although too small for chemical analysis even to appreciate, was sufficient to produce in bodies which contained it appreciable magnetic effects. MM. Thénard and La Place confirmed this remark. Brewster adds that, in justice to Coulomb, it is necessary to state that he is the undoubted author of the discovery that *all bodies, whether organic or inorganic, are sensible to the influence of magnetism.* M. Biot has remarked that there are two ways of explaining this, *either all substances in nature are susceptible of magnetism, or they all contain portions of iron, or other magnetic metals, which communicate to them this property.* This last explanation, though adopted by Coulomb, by no means affects his claim to the discovery of the general fact that all bodies, whether organic or inorganic, are susceptible of becoming magnetic. Prof. Hansteen has drawn from numerous experiments and observations the important conclusion that *every vertical object, of whatever material it is composed, has a magnetic south pole above, and a north pole below* (*Edin. Phil. Journal* for January–April 1821).

M. Arago made many valuable investigations concerning the influence of the aurora borealis on the needle, on the variations of the latter, upon the nature of meteors, lightning, the zodiacal light, magnetic storms, etc. etc., which are admirably recorded more particularly in the great work of Alex. von Humboldt. The latter remarks that Arago has left behind him a treasury of magnetical observations (upward of 52,600 in number) carried on from 1818 to 1835, which have been carefully edited by M. Fédor Thoman, and published in the "Œuvres Complètes de François Arago" (Vol. IV. p. 493). Much could be said, especially regarding Arago's paper, presented by him to the Academy of Sciences in 1811, which is considered to have established the foundation of chromatic polarization. Mention must at any rate be made of the fact that in Humboldt's estimation the discovery of the two kinds of polarization of light may be considered the most brilliant of the century. They, unquestionably, rank among the most splendid of optical phenomena.

Etienne Louis Malus, a distinguished French philosopher (Fifth Dissert. of "Encycl. Brit."), discovered in 1808 polarization by reflection from polished surfaces, and Arago, during 1811, made the discovery of coloured polarization. A world of wonder, remarks Humboldt, composed of manifold modified waves of light having new properties was now revealed. A ray of light which reaches our eyes, after traversing millions of miles from the remotest regions of heaven, announces of itself in Arago's polariscope (consisting of a plate of quartz cut across the axis placed in one end of a tube, at the other end of which is a doubly refracting prism) whether it is

reflected or refracted, whether it emanates from a solid or fluid, or gaseous body, even announcing the degree of its intensity (Delambre, "Histoire de l'Astronomie," p. 652; Humboldt, "Cosmos," 1849, Vol. I. p. 33; Vol. II. p. 715).

In 1818, Arago was elected a F.R.S.; he became a member of the Royal Astronomical Society and also member of the Bureau des Longitudes during 1822, was made Perpetual Secretary of the Academy and Director of the Paris Observatory eight years later, and received the Rumford medal in 1850. The Copley medal given him in 1825 had never before been conferred upon a Frenchman of science. It was upon his urgent request that the "Annuaire du Bureau des Longitudes" and "Les Comptes Rendus hebdomadaires" were commenced by the Academy, 1828–1835.

In a letter to Schumacher, Humboldt speaks of Arago as "one gifted with the noblest of natures, equally distinguished for intellectual power and for moral excellence." In conjunction with Gay-Lussac, Arago was, for almost half a century, Humboldt's most intimate friend, and their ever-increasing intimacy became such as to lead to a perfect unity of thought on scientific subjects. It cannot, therefore, be considered an exaggerated expression of feeling when, in a letter to Geoffroy St. Hilaire, dated Berlin, June 24, 1829, Humboldt should conclude with the words: "Pray remember me to MM. Valenciennes, Deleuze and Cuvier, but especially to him whom I hold dearest in this life, to M. Arago."

References.—Poggendorff, Vol. I. pp. 53, 54, and the several biographies named at p. 202, Vol. I of "Johnson's New Univ. Cycl.," 1877; J. A. Barral, "Œuvres de F. Arago," 1854–1855; Faria E. De e Arago, "Breve compendio . . ." Lisbon, 1800; Arago's "Notices Scientifiques," "Cat. Sc. Papers Roy. Soc.," Vol. I. pp. 80–84; Vol. IV. pp. 697–701; Vol. VI. pp. 567, 736–737; Vol. VIII. p. 537; "Encycl. Metropol.," Vol IV (Magnetism), pp. 6, 7; J. F. W. Herschel, "Nat. Phil.," 1855, pp. 117, 244, and his account of the repetition of M. Arago's experiments on rotatory magnetism in *Phil. Trans.* for 1825; Whewell, "Hist. Induc. Sci.," 1859, Vol. II. p. 226; *Phil. Mag.*, Vols. LIX. p. 233; LVII. pp. 40–49; LVIII. p. 50; LXI, p. 134; "Lib. Useful Knowledge' (Magnetism), p. 91; Noad, "Manual," pp. 204, 534; "Ann. of Sci Disc." for 1850, p. 124; Harris, "Rud. Magn.," Parts I, II. pp. 58–61 and *Phil. Trans.* for 1831, Part I; Prime's "Life of Morse," pp. 168, 265, 266; Gmelin's "Chemistry," Vol. I. p. 317; *Comptes Rendus* for 1836, Vol. II. p. 212; Dredge, "Electr. Illum.," Vol. II. p. 122; Sturgeon, "Scient. Res.," Bury, 1850, pp. 13, 37, 216, etc.; Appleton, "New Am. Cycl.," Vol. XI. p. 71; *Sci. Am. Suppl.*, No. 204, p. 3254; *La Lumière Electrique* for Oct. 31, p. 202; "Reports of the Smithsonian Institution" for 1857, pp. 102, 107; for 1862, pp. 132–143, and p. 127 of last named for Malus' discovery. Houzeau et Lancaster, "Bibl. Générale," Vol. I. part. i. pp. 676–677 detailing the contents of Arago's "Œuvres Complètes," published in thirteen volumes under the direction of J. A. Barral, also Vol. II. p. 76; *Cornhill Magazine*, Vol. XVII. p. 727; Pierre Prévost, "Tentative," Genève, 1822 (Poggendorff, Vol. II. p. 525); *Phil. Mag.*, Vol. LVIII. p. 50; Vol. LXI. p. 134; "Abstracts of Papers . . . Roy. Soc.," Vol. II. p. 249.

A.D. 1821.—Ridolfi (Marquis Cosimo di), an Italian agriculturist, is the author of several treatises on *fenomeni elettro-magnetici*, published in Florence, wherein he expresses the belief that "because electricity produces both magnetic and calorific phenomena, the elements giving these separately may possibly be so compounded together as to produce electricity; which infers that electricity is a compound of magnetism and caloric."

References.—"Antologia di Firenze," 1824, p. 159, and "Biblio. Ital.," Vol. LXIII. p. 268 for Ridolfi's description of the electric plate machine of Novellucci; also "Annales de Chimie et de Physique," Vol. X. p. 287; Sturgeon, "Scientific Researches," 1850, Sec. I. p. 29; "Bibliothèque Universelle" for Feb. 1821.

A.D. 1821.—Scoresby (Dr. William) (1789–1857), English master-mariner, and author of numerous scientific and other treatises, first publishes, in the "Trans. of the Edinburgh Society," accounts of his magnetometer—magnetimeter—and of his electro-magnetic experiments. These were duly followed up by full reports of his many interesting investigations relative, more particularly, to the development of magnetic properties of metals by percussion, as well as to magnetic induction, and regarding the uniform permeability of all known substances to the magnet's influence.

References.—"Abstracts of Papers . . . Roy. Soc.," London 1832–1833, Vol. II. pp. 108, 168, 210; "Dict. of Nat. Biog.," London, 1897, Vol. LI. p. 6; *Phil. Trans.* for 1822–1824; "Trans. Edin. Soc.," Vol. IX. pp. 243–258, 353, 465; Vol XI for 1824; Vol. XII for 1831; Vol. XIII for 1832, and Vol. XIV for 1833; "Brewster's Jour. of Sc.," Vol. VIII for 1828; "Bibliothèque Britannique," Genève, 1796, N.S., Vol. XXIX for 1825, p. 185; "Edin. Phil. Jour" for 1823, Vol. IX. p. 45.

A.D. 1821.—Babinet (Jacques) (1794–1872), French scientist, is the author of a very valuable treatise, published in Paris, upon the magnetical discoveries of Oersted, Ampère, Arago, Davy and others. This was followed by his "Résumé complet de la physique," etc., and by a companion work treating of the relations of ponderable and imponderable bodies to the phenomena of magnetism and electricity, also, during the year 1829, by his Memoir upon the determination of terrestrial magnetism.

He succeeded Savary as Professor at the Collège de France in 1838, and, two years later, took the place of Dulong in the section of General Physics at the Académie des Sciences, becoming not long after the Assistant Astronomer at the Paris Observatory for Meteorology.

His numerous scientific treatises are to be found throughout the "Mémoires de la Société Philomathique," the "Annales de

Physique," the "Comptes Rendus," the "Revue des Deux-Mondes" and other prominent publications of the day.

References.—Larousse, "Dict. Univ.," Vol. II. p. 10; "Eng. Cycl.," London, 1872, Supplement, p. 143; "Biog. Gén.," Vol. IV. p. 21; Mme. Blavatsky, "Isis Unveiled," Vol. I. p. 202; and Ronalds' "Catalogue," pp. 10–11, for the joint works of Ampère and Babinet.

A.D. 1821.—Pfaff (Christian Heinrich) (1773–1852), who became Professor of Medicine, Physics, etc., at the Kiel University, and was one of the most energetic followers of Volta, sends an unusually interesting communication to Gilbert's "Annalen der Physik" and to Schweigger's "Journal für Chemie und Physik," wherein he very ably supports the views of the Pavia physicist.

Pfaff had, long before that, become favourably known through numerous scientific papers, which were translated into the leading foreign journals, the ones entitled "Dissertatio inauguralis . . ." published at Stuttgart, and "Über thierische Elektricität," published at Leipzig, having brought him special distinction. He had also written, more particularly, upon the experiments made by Alex. von Humboldt as well as relative to Pacchiani's "Formation of Muriatic Acid by Galvanism," alluded to at the A.D. 1805 entry, and it was by reason of the investigations made by Pfaff and Van Marum that the use of the voltaic column was generally abandoned. These scientists had constructed very strong piles consisting, in some instances, of as many as seventy large separate discs, when they found that the lower layers of wet cloth or of pasteboard were so seriously compressed by the discs above them as to neutralize their effect.

References.—Johann Samuel T. Gehler's "Phys. Wörterbuch," Vol. VI. pp. 507, 517–518; "Roy. Soc. Cat. Sc. Papers," Vol. IV. pp. 866–871; "Ann. der Chemie," Vol. XXXIV. p. 307; Vol. LX. p. 314; "Annales de Chimie et de Physique," Vol. XLI. pp. 236–247; Sturgeon, "Annals," Vol. VIII. pp. 80, 146; Noad, "Manual," p. 558; Wilkinson, "Elements," Vol. I. pp. 1–8, 18, 22, 196, 326, 407; Vol. II. p. 106; "Encycl. Brit." ninth ed., Vol. XVIII. p. 725; "Soc. Philom.," Vol. II. p. 181; *Phil. Mag.*, Vol. XXVII. p. 338.

A.D. 1821.—Faraday (Michael), a very distinguished English chemist and natural philosopher (1791–1867), who probably did more for the development of the study of electrical science than any other investigator, publishes his "History of the Progress of Electro-Magnetism" and succeeds, on the morning of Christmas (December 25), 1821, both in causing a magnetic needle to rotate round a wire carrying an electric current and in making the wire rotate around the needle, thus rendering possible the production of continuous mechanical motion by electricity.

The apparatus with which he produced this result is described in nearly all works treating of natural philosophy. Premising his reference to this discovery of Mr. Faraday, whose original papers thereon appear in the *Quarterly Journal of Sciences and the Arts*, Vol. XII. pp. 75, 186, 283 and 416 (the first bearing date September 11, 1821), Dr. Whewell says that on attempting to analyze the electro-magnetic phenomena observed by Oersted and others into their simplest forms, they appeared, at least at first sight, to be different from any mechanical actions which had yet been observed. It seemed as if the conducting wire exerted on the pole of the magnet a force which was not attractive or repulsive, but *transverse ;* not tending to draw the point acted on nearer, or to push it further off, in the line which reached from the acting point, but urging it to move at right angles to this line. The forces appeared to be such as Kepler had dreamt of in the infancy of mechanical conceptions, rather than such as those of which Newton had established the presence in the solar system, and such as he, and all his successors, had supposed to be the only kinds of force which exist in nature. The north pole of the needle moved as if it were impelled by a vortex revolving round the wire in one direction, while the south pole seemed to be driven by an opposite vortex (called by Wollaston *vertiginous magnetism* and considered by Mr. Barlow as the result of *tangential action*). The case seemed novel, and almost paradoxical. It was soon established by experiments, made in a great variety of forms, that the mechanical action was really of this transverse kind. And a curious result was obtained, which a little while before would have been considered as altogether incredible : that this force would cause a constant and rapid revolution of either of the bodies about the other—of the conducting wire about the magnet, or of the magnet about the conducting wire (Vol. XII of the " Journal of the Royal Institution "; Watkins, " Popular Sketch of Electro-Magnetism; or Electro-Dynamics," London, 1828; Mrs. Somerville, " Connection of Phys. Sciences," 1846, p. 315).

Passing over many of Faraday's important scientific investigations in other lines, we come to his second great discovery, that of *magneto-electric induction*, which is the converse of Oersted's (developed by Ampère and Arago), the production of electricity by magnetism. This is recorded in the first series of " Experimental Researches in Electricity," read November 24, 1831 before the Royal Society, of which body Faraday had become a Fellow during 1824, and it is published at p. 125 of the *Phil. Trans.* for 1832.

It appears that upon observing certain phenomena, which he

described as *Volta-electric*, he concluded before long that magnetism in motion ought to produce an electric current just as electricity was made to imitate all the effects of magnetism. He carried on many experiments, and after the announcements made by Arago to the French Academy, November 22, 1824, he endeavoured to make the conducting wire of the voltaic circuit excite electricity in a neighbouring wire by induction, just as the conductor charged with common electricity would have done, but he obtained no satisfactory results until August 29, 1831 (*Annales de Chimie*, Vol. XLVIII. p. 402). He remarks: "Certain effects of the induction of electrical currents have already been recognized and described; as those of magnetism; Ampère's experiments of bringing a copper disc near to a flat spiral; his repetition, with electro-magnets, of Arago's extraordinary experiments, and perhaps a few others. Still it appeared unlikely that these could be all the effects which induction by currents could produce. . . . These considerations, with their consequence, the hope of obtaining electricity from ordinary magnetism, have stimulated me at various times to investigate experimentally the inductive effects of electric currents. I lately arrived at positive results, and not only had my hopes fulfilled, but obtained a theory which appeared to me to open out a full explanation of Arago's magnetic phenomena, and also to discover a new state which may probably have great influence in some of the most important effects of electric currents." His very important conclusion was finally verified, October 1–17, in the following manner. He had taken a helix, or spool of copper wire, which latter, Prof. Brande tells us, was covered with silk as in his former experiments and which was connected by its extremities with a galvanometer, the deflection of which would of course announce a current of electricity in the spiral and wires connected with it, and he found that while in the act of introducing the pole of a powerful bar-magnet within the coils of the spiral, a deflection of the galvanometer took place in one direction, and that when in the act of withdrawing, it took place in the opposite direction; so that each time the conducting wire cut the magnetic curves, a current of electricity was, for the moment, produced in it. Dr. Whewell's account of the discovery is so well interspersed with references that it deserves repetition here:

"In 1831, Faraday again sought for electro-dynamical induction, and, after some futile trials, at last found it in a form different from that in which he had looked for it. It was then seen, that at the precise time of making or breaking the contact which closed the galvanic circuit, a momentary effect was induced in a neighbouring wire, but disappeared instantly (*Phil Trans.*,

1832, p. 127, 1st ser., Art. 10). Once in possession of this fact, Mr. Faraday ran rapidly up the ladder of discovery, to the general point of view. Instead of suddenly making or breaking the contact of the inducing circuit, a similar effect was produced by removing the inducible wire nearer to or further from the circuit (Art. 18)—the effects were increased by the proximity of soft iron (Art. 28)—when the soft iron was affected by an ordinary magnet, instead of the voltaic wire, the same effect still recurred (Art 37)—and thus it appeared, that by making and breaking magnetic contact, a momentary electric current was produced. It was produced also by moving the magnet (Art. 39)—or by moving the wire with reference to the magnet (Art. 53). Finally, it was found that the earth might supply the place of a magnet in this as in other experiments (2nd ser., *Phil. Trans.*, p. 163) and the mere motion of a wire, under proper circumstances, produced in it, it appeared, a momentary electric current (Art. 141). These facts were curiously confirmed by the results in special cases. They explained Arago's experiments: for the momentary effect became permanent by the revolution of the plate. And without using the magnet, a revolving plate became an electrical machine (Art. 150), a revolving globe exhibited electro-magnetic action (Art. 164), the circuit being complete in the globe itself without the addition of any wire; and a mere motion of the wire of a galvanometer produced an electro-dynamic effect upon its needle (Art. 171). . . . And thus he was enabled, at the end of his second series of 'Researches' (December 1831), to give, in general terms, the law of nature to which may be referred the extraordinary number of new and curious experiments which he has stated (Arts. 256–264), namely, that if a wire move so as to cut a magnetic curve, a power is called into action which tends to urge a magnetic current through the wire; and that if a mass move so that its parts do not move in the same direction across the magnetic curves, and with the same angular velocity, electrical currents are called into play in the mass. And here might properly be added the experimental distinction between a helix and a magnet, which Faraday subsequently pointed out ('Exper. Res.,' Art. 3273): 'Whereas an unchangeable magnet can never raise up a piece of soft iron to a state more than equal to its own, as measured by the moving wire, a helix carrying a current can develop in an iron core magnetic lines of force of a hundred or more times as much power as that possessed by itself when measured by the same means.'"

An article on the reduction of Mr. Faraday's discoveries in magneto-electric induction to a general law appeared in the "Philosophical Transactions of the Royal Society," Vol. III. p. 37, and at Vol. IV. p. 11, new series, of the *Philosophical Magazine* (see Faraday's

first two Memoirs in the *Phil. Trans.*, Book XIII. chaps. v and viii; letter to Gay-Lussac in *Annales de Chimie*, Vol, LI. 1832, pp. 404–434; *Phil. Mag.*, Vol. XVII. pp. 281, 356); while, in the *Phil. Trans.* for 1832, p. 132, is the Report of his production of the electric spark through a modified arrangement in which the electric current was induced by an electro-magnet, as shown in his subsequent work published in London during 1834. This is alluded to in Vol. V. pp. 349–354 of the *Phil. Mag.* for latter year, and in Poggendorff's *Annalen*, Vol. XXXIV. pp. 292–301 for 1835. (See also Bakewell, "Elect. Science," pp. 39, 140, 144.)

> "Around the magnet, Faraday
> Is sure that Volta's lightnings play;
> But how to draw them from the wire?
> He took a lesson from the heart
> 'Tis when we meet—'tis when we part,
> Breaks forth the electric fire."
>
> HERBERT MAYO, in *Blackwood.*

In Prof. Alfred M. Mayer's address, delivered before the American Association at Boston, August 26, 1880, we read: "It is not generally known or appreciated that Henry and Faraday independently discovered the means of producing the electric current and the electric spark from a magnet. Tyndall, in speaking of this great discovery of Faraday, says: 'I cannot help thinking while I dwell upon them, that this discovery of magneto-electricity is the greatest experimental result ever obtained by an investigator. It is the Mont Blanc of Faraday's own achievements. He always worked at great elevations, but higher than this he never subsequently attained.' And it is this same physicist who further remarks ('Johnson's Cycl.,' Vol. II. pp. 26–27) that all our induction coils, our medical machines, and the electric light so far as it has been applied to lighthouses, are the direct progeny of Faraday's discovery. In the paper here referred to (Nov. 24, 1831) he for the first time calls the 'magnetic curves,' formed when iron-filings are strewn around a magnet, 'lines of magnetic force.' All his subsequent researches upon magnetism were made with reference to those lines. They enabled him to play like a magician with the magnetic force, guiding him securely through mazes of phenomena which would have been perfectly bewildering without their aid. The spark of the *extra current,* which I believe was noticed for the first time by Prof. Joseph Henry, had been noticed independently by Mr. William Jenkin. Faraday at once brought this observation under the yoke of his discovery, proving that the augmented spark was the product of a secondary current evoked by the reaction of the primary upon its own wire." The

phenomenon of the spark from the *extra current* here alluded to was first announced by Henry in July 1832. He had observed that when the poles of a battery are united by means of a short wire of low resistance, no spark or at least a very faint one is produced, but when the poles of the battery are connected by a long copper wire and mercury cups, a brilliant spark is obtained at the moment the circuit is broken by raising one end of the wire out of its cup of mercury and also that the longer the wire and the greater the number of its helical convolutions, the more powerful would be the effect (Silliman, "Am. Jour. of Sc.," Vol. XXII). The results of Faraday's investigation of the *extra current* first appeared in the *Phil. Mag.* for November 1834.

The references already named give an account of many other important results attained by Faraday during 1831 and up to the date of the publication of the third series of his "Experimental Researches" (p. 76), wherein he recognizes the "Identity of Electricities derived from different sources"[1] (Vol. I. par. 265 and 360), after investigating the electricities of the machine, the pile, and of the electrical fishes, and after employing as conductors the entire plant of the metallic gas pipes and water pipes of the city of London (*Phil. Trans.* for 1833, p. 23; Poggendorff, *Annalen,* Vol. XXIX, 1833, pp. 274, 365).

In the fourth series, relating to "A New law of electric conduction" (Vol. I. par. 380, 381, 394, 410), he demonstrates the influence of what is called "the state of aggregation" upon the transmission of the current. He found that although the latter was conveyed through water it did not pass through ice. This he subsequently explained by saying that the liquid condition enables the molecule of water to turn round so as to place itself in the proper line of polarization, which the rigidity of ice prevents. This polar arrangement must precede decomposition, and decomposition is an accompaniment of conduction (*Phil. Trans.* for 1833, p. 507; Poggendorff, *Annalen,* Vol. XXXI, 1834, p. 225; also *Phil. Mag.,* Vol. X. p. 98; "Royal Inst. Proc.," Vol. II. p. 123; Silliman's *Journal,* Vol. XXI. p. 368).

Other series (pars. 309, 450, 453–454, 472, 477, 661–662, 669, etc.) treat of "Electro-chemical or electrolytic decomposition." The experiments of Wollaston in this line have been given under the A.D. 1801 date, where Prof. Faraday's opinion of them is also expressed. Faraday was successful in the employment of Wollaston's apparatus for the decomposition of water, and he afterwards

[1] See the 1839 ed. of "Experimental Researches": I, "Voltaic Electricity," par. 268; II, "Ordinary Electricity," par. 284; III, "Magneto-Electricity," par. 343; IV, "Thermo-Electricity," par. 349; V, "Animal Electricity," par. 351.

devised an arrangement enabling him to effect true electro-chemical decompositions by common electricity as well as by the voltaic pile. For this, it is said, he used an electric battery consisting of fifteen jars and a plate machine having two sets of rubbers and a glass disc fifty inches in diameter, the whole presenting a surface of 1422 inches. One revolution of the plate could be made to give ten or twelve sparks, each one inch long, while the conductors afforded sparks ten to fourteen inches in length. He also devised a *discharging train*, to instantaneously carry off electricity of the feeblest tension by connecting a thick wire as he had previously done with the London gas and water pipes. A good description of the methods by which he succeeded with the latter apparatus in establishing the analogy between ordinary and voltaic electricity is given in the eighth "Britannica," Vol. VIII. pp. 596–597. He had shown, at paragraph 371 and p. 105 of his "Researches," that as a measure of quantity, a voltaic group of two small wires of platinum and zinc, placed near each other, and immersed in dilute acid for three seconds, yields as much electricity as the electrical battery, charged by thirty turns of a large machine; a fact that was established both by its momentary electro-magnetic effect, and by the amount of its chemical action, but, in order to enable him to establish a principle of definite measurement, he devised a *voltameter* or *volta-electrometer* as mentioned at paragraph No. 739 (Noad, "Manual," p. 365). By means of this apparatus he calculated that a single grain of water in a voltaic cell will require for its decomposition a quantity of electricity equal to that liberated in 800,000 discharges of the great Leyden battery of the Royal Institution ("Researches," par. 861). Also, that the decomposition of a single grain of water by four grains of zinc in the active cell of the voltaic circle, produces as great an amount of polarization and decomposition in the cell of decomposition, as 950,000 charges of a large Leyden battery, of several square feet of coated surface; an enormous quantity of power, equal to a most destructive thunderstorm. Tyndall remarks ("Notes on Electricity," No. 118, also "Faraday as a Discoverer," 1868, p. 44) that Weber and Kohlrausch ascertained that the quantity of electricity associated with one milligramme of hydrogen in water, if diffused over a cloud 1000 metres above the earth, would exert, upon an equal quantity of the opposite electricity at the earth's surface, an attractive force of 2,268,000 kilogrammes.[1]

Faraday introduced new terms to express more specifically the circumstances attending electro-chemical decomposition. Objections had long been made to the designation *poles*—one *positive*,

[1] In English measure, the metre is $1\frac{1}{11}$ yd., the milligramme is $\frac{1}{65}$ of a grain; the kilogramme is 2 lb. $3\frac{1}{4}$ oz.

the other *negative*—on the ground that such did not convey a correct idea of the effects produced. These designations had been given under erroneous supposition that the poles exerted an attractive and repulsive energy towards the elements of the decomposing liquid, much as the poles of the magnet act towards iron. When connecting the extremities of a battery, the electricity simply makes a circuit; the current passes *through* the substance to be decomposed and the elements remain in operation until the connection is broken. Since the poles merely act as a path to the current he calls them electrodes (*electron*, electricity, *odos*, a way); that part of the surface of the decomposing matter which the current enters—immediately touching the positive pole—he designates as *anode* (*ana*, upward) and the part of the matter which the current leaves—next to the negative pole—*cathode* (*kata*, downward). He names *electrolyte* (*luo*, to set free) the fluid decomposed directly by electricity passing through it; the term *electrolyzed* meaning electro-chemically decomposed. The elements of an *electrolyte* are named *ions* (*ion*, going), the *anion* being the body (in sulphate of copper solution, the acid) which *goes up* to the positive pole, to the *anode* of the decomposing body, whilst the *cation* is that (in sulphate of copper solution, the metal) which *goes down* to the negative pole, to the *cathode* of the decomposing body.

The many tests which he made with his voltameter led him to the conclusion "that under every variety of circumstance, the decompositions of the voltaic current are as definite in their character as those chemical combinations which gave birth to the atomic theory" (*Phil. Trans.* for 1833, p. 675; for 1834, p. 77; Poggendorff, *Annalen*, Vols. XXXII. p. 401; XXXIII. pp. 301, 433, 481; Bakewell, "Electric Science," p. 124; "Brit. Assoc. Report" for 1833, p. 393; Henry's "Memoirs of Dalton," p. 106).

The eighth series of his "Researches" (Vol. I. pars. 875, etc.) treats of the "electricity of the voltaic pile," a further investigation of which is shown through the papers constituting his sixteenth and seventeenth series as per Index of Vol. II. p. 302. Faraday establishes by very simple experiments the most powerful known refutation of Volta's contact theory and shows conclusively that the current in the pile results from the mutual chemical action of its elements, just as Fabbroni and Wollaston had stated before him. An extract from the conclusion of his very elaborate defence of the chemical theory reads as follows: ". . . the contact theory assumes, that a force which is able to overcome powerful resistance . . . can arise out of nothing: that, without any change in the acting matter, or the consumption of any generating force, a current can be produced, which shall go on for ever against a constant resistance, or

only be stopped as in the voltaic trough, by the ruins which its exertion has heaped upon its own course. . . . The chemical theory sets out with a power, the existence of which is pre-proved, and then follows its variations, rarely assuming anything which is not supported by some corresponding simple chemical fact. The contact theory sets out with an assumption to which it adds others, as the cases require, until at last the contact force, instead of being the firm unchangeable thing at first supposed by Volta, is as variable as chemical force itself. Were it otherwise than it is, and were the contact theory true, the equality of cause and effect must be denied. Then would perpetual motion also be true; and it would not be at all difficult, upon the first given case of an electric current by contact alone, to produce an electro-magnetic arrangement, which, as to its principle, would go on producing mechanical effects for ever" ("Exp. Res.," pars. 2071–2073, Vol. II. pp. 103–104; *Phil. Trans.* for 1834, p. 425; for 1840, pp. 61, 93; Poggendorff, *Annalen*, Vols. XXXV. pp. 1, 222; LII. pp. 149, 547; LIII. pp. 316, 479, 548. Auguste Arthur De la Rive, "Archives de l'Elect.," Genève, 1841–1845, Vol. I. pp. 93, 342; Graham, "Elem. of Chem.," London, 1850, Vol. I. pp. 242, etc.; Faraday and Sturgeon, "Ann. of Elec.," Vol. IV. pp. 229, 231; Daniell, "Intro. to Study of Chem. Phil."; Liebig, *Annal.*, Vol. XXXVI. p. 137; Figuier, "Expos. et Hist.," 1857, Vol. IV. p. 434. Also De la Rive's "Treatise," Vol. I. pp. 393–402; "Exper. Researches," Vol. I. pp. 322–323—induction of galvanic current upon itself).

Faraday's theory of induction offers nothing new as to the nature of the electric forces—it simply indicates the manner of their distribution and the laws by which they are affected. His experiments show that electrization by influence is possible only by means of continuous particles of air or other non-conducting medium (dielectric), that no electric action occurs at a distance greater than the interval existing between two adjacent molecules of such medium, in which latter a true polarization of the particles takes place, and that it is by means of this polarization that electric force is transferred to a distance. Induction only takes place through insulators: induction is insulation, it being the action of a charged body upon insulating matter, of which latter the particles communicate to each other in a very minute degree the electric forces whereby they become polarized and are enabled to transmit an equal amount of the opposite force to a distance. The latter property is termed *inductive force* or *specific inductive capacity*, and Faraday discovered that the intensity of electric induction varies in different insulating media; for instance, the induction through shell-lac (the first substance he experimented with) being

twice as great as through a like thickness of air. It was while experimenting with shell-lac that he first observed the singular phenomenon of the *return* or *residual charge,* i. e. the charge which would of itself gradually reappear in the apparatus after the latter had been suddenly and perfectly discharged. This, he considered due to the penetration, into the substance of the dielectric, of a portion of the charge by conduction. The inductive capacity of all gases he found to be the same as that of air, and this property does not alter with variations in their density.

His discovery of the specific inductive capacity of various substances has been already alluded to (A.D. 1772, Cavendish). Faraday's biographer in the ninth " Britannica " says : " It appears, from hitherto unpublished papers, that Henry Cavendish had, before 1773, not only discovered that glass, wax, rosin and shell-lac have higher specific inductive capacities than air but had actually determined the numerical ratios of these capacities. This, of course, was not known to Faraday or other electricians of his time." It was on the 30th of November, 1837, Faraday communicated to the Royal Society the paper on Induction wherein he announces the re-discovery of *specific inductive capacity.* One of its most important results to-day, remarks John Tyndall, " is the establishment of the specific inductive capacity of insulators—a subject of supreme importance in connection with submarine cables. As a striking illustration of Faraday's insight, it may be mentioned that as early as 1838 he had virtually foreseen and predicted the retardation produced by the inductive action between the wires of submarine cables and the surrounding sea-water " (Tyndall's " Notes on Electricity," 1871, pp. 160–161 ; " Exper. Researches," Index Vol. I. ; " Faraday as a Discoverer," new edition, p. 89). Consult, also, the references entered at Cavendish, A.D. 1772 ; J. E. H. Gordon, " Phys. Treatise on Elect. . . ." London, 1883, Vol. I. chap. xi. par. 81–83, which alludes to " Exper. Researches," 1161, Vol. I. p. 360 as well as to the investigations of specific inductive capacities made by Boltzmann, Romich and Fajdiga, Romich and Nomak, Schiller, Silow, Wüllner, Dr. Hopkinson, J. E. H. Gordon, Ayrton and Perry, and gives the " General Table of Specific Inductive Capacities," detailing the observations of Cavendish, Faraday and all the others named above. See, besides, " Reprint of Papers . . ." Sir Wm. Thomson, 1872 to 1884, 2nd ed., paragraphs 36, 46, 50 ; *Phil. Trans.*, 1838, pp. 1, 79, 83, 125 ; 1842, p. 170 ; Poggendorff, *Annalen*, Vols. XLVI. pp. 1, 537 ; XLVII. pp. 33, 271, 529 ; XLVIII. pp. 269, 424, 513 ; XCVI. p. 488 ; XCVII. p. 415 ; *Phil. Mag.*, Vols. IX. p. 61 ; XI. p. 10 ; XIII. pp. 281, 355, 412 ; " Bibl. Univ.," Vol. XVII. p. 178 and " Archives des Sc. Phys.," Vol. XXXI. p. 48 ;

"Journal de Pharm.," Vol. XXVII. p. 60; W. S. Harris, "Specific Inductive Capacities . . ." (*Phil. Trans.*, 1842).

In the fifteenth series of his "Exper. Researches" (Vol. II. pars. 1749–1795), Faraday gives the results of his experiments proving the identity of the power of the *gymnotus* or the *torpedo* with common electricity. He concludes that "a single medium discharge of the fish is at least equal to the electricity of a Leyden battery of fifteen jars, containing 3500 square inches of glass coated on both sides, charged to its highest degree" (p. 8); "all the water and all the conducting matter around the fish, through which a discharge circuit can in any way be completed, is filled at the moment with circulating electric power and this state might be easily represented generally in a diagram by drawing the lines of inductive action upon it. In the case of a *gymnotus* surrounded equally in all directions by water, these would resemble generally in disposition the magnetic curves of a magnet having the same straight or curved shape as the animal, that is, provided he in such cases employed, as may be expected, his four electric organs at once" (p. 12) (C. Matteucci, "Traité des phénom. . . ." Paris, 1844, pp. 188–192).

Then follow in due course, Faraday's remarkable papers relating to the magnetization of light and the illumination of magnetic lines of force, the polar and other condition of diamagnetic bodies, etc. These communications, which he made to the Royal Society in November and December 1845, contain the particulars of what many consider to be his most brilliant discoveries. He first shows that when a ray of polarized light passes through a piece of silicated borate of lead glass placed between the poles of a natural (or preferably an electro-) magnet, so that the line of magnetic force shall pass through its length, the polarized ray will experience a rotation. The law is thus expressed: "If a magnetic line of force be *going* from a North pole or *coming* from a South pole, along the path of a polarized ray, coming to the observer, it will rotate that ray to the right hand, or if such a line of force be coming from a North pole or going from a South pole it will rotate such a ray to the left hand" (*Phil. Trans.* for 1846 and 1856; Poggendorff, *Annalen*, Vol. C. pp. 111, 439; Noad, "Manual," pp. 804–805; Harris, "Rud. Mag.," Parts I and II. p. 71; Whewell, "Hist. of the Inductive Sciences," Vol. II. pp. 111, 133; Gmelin's "Chemistry," Vol. I. pp. 168–169). At the Faraday Centenary Celebration held in London, June 18, 1891, Lord Rayleigh observed that "the full significance of the last-named discovery was not yet realized. A large step towards realizing it, however, was contained in the observation of Sir William Thomson, that the rotation of the plane of polarization proved that something in the nature of rotation must be going on within the

medium when subjected to the magnetizing force, but the precise nature of the rotation was a matter for further speculation, and perhaps might not be known for some time to come."

Through Faraday's other communication, is made known the discovery of *diamagnetism.* Therein he shows, as the result of his customary careful experimental explorations that the magnetism of every known substance (even tissues of the human frame) is manifested in one of two ways. Either the body is, like iron, attracted by the magnet, taking a position coincident with the magnetic forces which he calls *paramagnetic* (*para* beside or near, *magnetes, magnes,* magnet) or bodies—like bismuth, for instance—are repelled by the poles and should therefore be called *diamagnetic* (*dia,* across) for they set themselves across, equatorially, or at right angles to the magnetic lines. As far back as 1788, the repulsion by bismuth was first observed by Brugmans, while M. Becquerel, during 1827, confirmed the observation, said to have been made by Coulomb, that a needle of wood could be made to point across the magnetic curves, and stated that he had found such a needle place itself parallel to the wires of a galvanometer. Yet, neither M. Becquerel nor M. Lebaillif, who (after Saigy and Seebeck) had called attention to the repulsion of both bismuth and antimony by the magnet, made a distinction of the diamagnetic force from the paramagnetic as Faraday did. Amongst other results, this English scientist found that phosphorus is at the head of all diamagnetic substances, bismuth taking the lead amongst the metals, whilst, of many gases and vapours, oxygen proved to be the least diamagnetic, in fact, the only one which is paramagnetic ("Lond., Edin., and Dub. Phil Mag." for December 1850). All the facts set forth in Mr. Faraday's paper are, according to Brande, resolvable by induction into the general law; that while every particle of a magnetic body is attracted, every particle of a diamagnetic body is repelled by either pole of a magnet : these forces continue as long as the magnetic power is sustained, and cease on the cessation of that power, standing therefore in the same general antithetical relation to each other as the positive and negative conditions of electricity, the northern and southern polarities of ordinary magnetism, or the lines of electric and magnetic force in magneto-electricity (*Phil. Trans.* for 1846–1851; *Phil. Mag.*, Vols. XXVIII. pp. 294, 396, 455; XXIX. pp. 153, 249; XXXVI. p. 88; *Annales de Chimie,* Vol. XVII. p. 359; Poggendorff, *Annalen,* Vols. LXVIII. p. 105; LXX. p. 283; LXXXII. pp. 75, 232; "Bibl. Univ. Archives," Vols. I. p. 385; III. p. 338; XVI. p. 89; Ludwig F. von Froriep, "Notizen," Vols. XXXVII. cols. 6–8; XXXIX. col. 257; Erdmann, "Jour. Prak. Chem.," Vol. XXXVIII. p. 256; Liebig, *Annal.*,

Vol. LVII. p. 261; Napoli, "Rendiconto," Vol. VI. p. 227; Silliman's "Journal," Vols. II. p. 233; X. p. 188; Walker, "Elect. Mag.," Vol. II. p. 259; John Tyndall, "Researches on Diamagnetism and Magne-crystallic Action," London, 1870, pp. 1, 38, 89, 90, 137; Whewell, "Hist. of Ind. Sc.," 1859, Vol. II. p. 620; "Athenæum" for January 31, 1846; Plücker's paper "On the relation of Magnetism and Diamagnetism," dated September 8, 1847, in Poggendorff's *Annalen* and in Taylor's "Scientific Memoirs," Vol. V. part ix. p. 376; Edmond Becquerel's "Memoir on Diamagnetism" in *An. de Ch. et de Ph.*, Vol. XXXII. p. 112; "Practical Mech. and Engin. Mag.," 1846, p. 117; for "Coexistence of Paramagnetism and Diamagnetism in same Crystal," *see* "Jour. of Chem. Soc.," London, February 1906, p. 69, taken from *Les Comptes Rendus*).

During the course of Faraday's experiments to ascertain the effects of magnetism on crystals some very curious results were obtained with bismuth. Having suspended four bars of the metal horizontally between the poles of the electro-magnet, the first pointed *axially;* the second *equatorially;* another *equatorial* in one position, and *obliquely equatorial* if turned round on its axis fifty or sixty degrees; the fourth *equatorially and axially* under the same treatment; whilst all of them were repelled by a single magnetic pole, thus showing their strong and well-marked diamagnetic character. These variations were attributed to the regularly crystalline condition of the bars. He then chose carefully selected crystals and, after describing their peculiar action between the poles, he says that "the results are altogether very different from those produced by diamagnetic action. They are equally distinct from those dependent on ordinary magnetic action. They are also distinct from those discovered and described by Plücker, in his beautiful researches into the relation of the optic axis to magnetic action; for there the force is equatorial, whereas here it is axial. So they appear to present to us a new force, or a new form of force in the molecules of matter, which, for convenience' sake, I will conventionally designate by a new word, as the *magne-crystallic force.*" Prof. A. M. Mayer justly observes ("Johnson's Cycl.," I. 1342) that the above-named facts "received their full explanation at the hands of Tyndall, whose subtile examination or lucid explanation of these phenomena—though not popularly known—we think form his greatest claim to illustrious distinction as a man of science." For an extract from the last-named work relative to M. Poisson's remarkable theoretic prediction of magne-crystallic action, see the article concerning that scientist at A.D. 1811. (Consult *Phil. Trans.* for 1849, pp. 4, 22; *Phil. Mag.*, Vol. XXIV. p. 77 and s. 4, Vol. II. p. 178; De la Rive, "Treatise," Vol. I. pp. 482–497;

"Athenæum," No. 1103, p. 1266; Gmelin's "Chemistry," Vol. I. pp. 514–519.)

The remarkable discoveries we have named were succeeded by many others of a very high order, the references to which occupy as many as 158 separate entries through pp. 555–560, Vol. II. of the "Catal. of Sci. Papers of the Royal Society." Among those may be singled out his additional investigations regarding the magnetism of gases and the magnetic relations of flames and gases, the lines of magnetic force, subterraneous electro-telegraphic wires (*Phil. Mag.* s. 4, Vol. VII. 1854), the relation of gravity to electricity, atmospheric magnetism, likewise his recorded observations on hydro-electricity, magneto-electric light for lighthouses, pyro-electricity, the electrophorus, Wheatstone's telegraph, etc. ("Roy. Inst. Proc." for 1854–1858, pp. 555–560). It was in 1848 he wrote of the powerful insulating properties of gutta-percha (Gmelin's "Chemistry," Vol. I. p. 313; "Lond. and Edin. Phil. Mag.," Vol. XXXII. p. 165), and he not long after constructed a very singular apparatus to a Leyden jar consisting of a wire 140 miles long, perfectly insulated with gutta-percha, one end of which communicated with an insulated pile of 360 elements of zinc and copper charged with acidulated water, as described in the "Britannica." The results of his inquiries concerning the Leyden jar charge of buried electric conducting wires were, according to Whitehouse's pamphlet on the Atl. Tel. (p. 5) communicated to the Roy. Inst. during the year 1854.

The life of Michael Faraday is an admirable example of extraordinary successes achieved through patient endeavour and constancy of purpose over unusual obstacles of birth and education. M. Dumas, in the sixteenth volume of the London "Chemical News," tells us he was the only man in England who raised himself to the first rank in science, whose every attribute can be fearlessly held up as a model. He had none of the "ambition, eternal pining after rank or hauteur" of Davy, nor "the secretiveness and coldness" of Wollaston. "Faraday's intellect, while it burnt as brightly as Davy's, was as deep searching as Wollaston's, and as reverent as Newton's, yet it had nothing in it which could repel us, chill us, or forbid our affection." The son of a blacksmith, he was first placed in a bookseller's shop, then apprenticed to a bookbinder, but his tastes were averse to the trade and he was led to seek instruction in another line, more particularly after attending the evening lectures of Mr. Tatum, yet, as already stated (see Dr. George Gregory, A.D. 1796), it was while in M. Riebau's (the bookbinder's) employ that chance threw in his way the works which led him to enter the channels in which he subsequently became so distinguished. To a friend, he writes :

"Your subject interested me deeply every way; for Mrs. Marcet was a good friend to me, as she must have been to many of the human race. I entered the shop of a bookseller and bookbinder at the age of thirteen, in the year 1804, remaining there eight years, and during the chief part of the time bound books. Now it was in those books, in the hours after work, that I found the beginning of my philosophy. There were two that especially helped me, the 'Encyclopædia Britannica,' from which I gained my first notions of electricity, and Mrs. Marcet's 'Conversations on Chemistry,' which gave me my foundation in that science. Do not suppose that I was a very deep thinker, or was marked as a precocious person . . . but facts were important to me and saved me. I could trust a fact and always cross-examined an assertion. So when I questioned Mrs. Marcet's book by such little experiments as I could find means to perform, and found it true to the facts as I could understand them, I felt that I had got hold of an anchor in chemical knowledge, and clung fast to it . . ." ("Faraday as a Discoverer," by John Tyndall, 1868, pp. 6–7).

Think of the startling, not to say marvellous, achievements growing out of Faraday's subsequent first experiments with an electrical machine made out of an old bottle and by the aid of a Leyden jar constructed with a medicine phial!

In 1812, he was taken by Mr. Dance to the lectures of Sir Humphry Davy, whose chemical assistant he became the following year and in whose company, as we have already seen (A.D. 1801), he travelled on the Continent until 1815. Mr. Davies Gilbert, to whom is due Davy's introduction to the Royal Institution, has said of the last-named illustrious philosopher that the greatest of all his discoveries was the discovery of Faraday. In 1816, Michael Faraday was placed by Mr. Brande in charge of the "Quarterly Journal of Science," and, during 1823, he was elected corresponding Member of the French Academy, becoming F.R.S. the ensuing year through the influence of his friend Richard Phillips. It was during 1825–1826 he published in the *Phil. Trans.* the chemical papers wherein he announces the discovery of benzole (called by him bicarburet of hydrogen) to which, says Hoffmann, "we virtually owe our supply of aniline, with all its magnificent progeny of colours." In 1827, Faraday succeeded Davy as lecturer at the Royal Institution, and, from 1829 to 1842, he occupied the post of chemical lecturer at the Royal Military Academy, Woolwich. The "Experimental Researches," to which we have so often alluded, first appeared in the 1831 *Phil. Trans.*, and were afterwards collected in three volumes, which were published respectively during 1839, 1844, 1855. Faraday was made D.C.L. in 1832 by Oxford University, and, one

year later, he received the Fullerian professorship of chemistry in the Royal Institution, which he held till his death. A pension was given him by the English Government in 1835, and he also received the Royal Medal, which latter was again conferred upon him, together with the Rumford Medal, during 1846. Ten years before (1836) he had become a member of the Senate of the London University, and during the year 1858 the Queen allotted him the residence in Hampton Court where he died in 1867. "Taking him for all in all," says Tyndall, "it will, I think, be conceded that Faraday was the greatest experimental philosopher that the world has ever seen; and I would hazard the opinion that the progress of future research will tend not to diminish but to enhance the labours of this mighty explorer."

References.—"Life of Faraday," by Dr. H. Bence Jones (Sec. R.I.); "Michael Faraday," by Dr. J. H. Gladstone, 1872; "Faraday as a Discoverer," by John Tyndall; the biographical sketch by Prof. Joseph Lovering; "Michael Faraday, his Life and Work," by Silv. P. Thompson, New York, 1898; "The Chemical News" (Am. Rep.), Vol. I. pp. 246, 250, 276, and Vol. II. pp. 98, 202; Report of the Faraday Centenary celebration at the London Roy. Inst., June 17, 1891; Poggendorff, Vol. I. pp. 719–722; Larousse, "Dict. Univ.," 1872, Vol. VIII. p. 99; "Biog. Gén.," Vol. XVII. pp. 90–93; "Men of the Time," London, 1856; Reports on Faraday's Lectures delivered before the Roy. Inst. (taken from the "London Mining Journal," Nos. 714, 717–722), at pp. 319–324, 387–393; Vol. XVIII for 1849 of "Jour. of Frankl. Inst."; Gmelin's "Chemistry," Vol. I. pp. 424, etc., 435–436, 514–519; Poggendorff, *Annalen*, Vols. LXXXVIII. p. 557; Ergänz, Vol. I. pp. 1, 28, 64, 73, 108, 187, 481–545; Gustav Wiedemann, "Die Lehre von Galv.," 1863 and "Die Lehre von der Elektricität," 1883; W. H. Uhland, "Die Elektrische Licht," 1884, p. 62; An. Sc. Dis. for 1850, pp. 129, 131, 132; for 1851, p. 133, and for 1852, p. 110 on "Atmospheric Magnetism," taken from "Jameson's Journal," July 1851; for 1853, p. 132; for 1856, p. 161; for 1858, p. 177, Faraday, "On the Conservatism of Force"; for 1860, p. 125, Faraday on "Static Induction"; for 1863, p. 108, "Elec. Lamp in Lighthouses"; for 1868, p. 169; for 1870, p. 10; for 1874, p. 174, on "Dielectric Absorption"; Robison, "Mechan. Phil."; Leslie, "Geomet. Anal."; "Jour. Roy. Inst." for February 1831, Vol. I. p. 311 (Electrif. of ray of light); eighth "Britannica," Vols. I, sixth dissertation; VIII. pp. 532–533, 539, 542, 544, 552, 601, 607, 617; XIV. pp. 68, 663; XXI. pp. 612, 622, 628, 630; ninth "Britannica," Vol. IX. pp. 29–31; Brockhaus, "Conversations-Lexikon," Vol. VI. pp. 565–566; "Lond. and Edin. Ph. Mag.," Vol. I. p. 161 for letter of Faraday of July 27, 1832, enclosing one signed P. M., "in which *chemical decomposition is for the first time obtained by the induced magnetic current*"; Faraday and Schönbein ("London and Edin. Mag.," July–August 1836; "Roy. Instit. Proc.," III. 70–71); Faraday and Riess, "On the action of non-conducting bodies in electric induction," 1856; Sturgeon, "Sc. Res.," 1850, pp. 20, 475; "Practical Mechanic," Vols. II. pp. 318, 408; III. p. 197; "Libr. of Useful Knowledge" (Elec. Mag.), pp. 18, 99; Humboldt, "Cosmos," Vol. I. pp. 182, 188; Harris, "Rud. Magn.," 1852, I and II, pp. 61–69, etc., 199; III. 122–128 and "Rud. Elec.," 1st ed., pp. 33–34; "Edin. Jour. Sc.," 1826, Vol. III. p. 373; "Edin. new Ph. Jour.," Vol. LI. p. 61; Golding Bird's "Nat. Phil.," p. 227; James Johnstone, "The Ether Theory of 1839," pp. 26, 37; Noad, "Manual," pp. 59, 236, 692, 805, 866; "Am. Jour. Sc." for April

1871, relative to lines of magnetic force; "Ann. of Phil." for 1832; "Bibl. Univ. Archives," Vol. XVI. p. 129; "Roy. Instit. Proc.," Vol. I, 1851–1854, pp. 56, 105, 216, 229; *Phil. Trans.*, 1832, p. 163; 1851, pp. 29, 85; 1852, pp. 25, 137; *Phil. Mag.*, Vol. III, 1852, p. 401; Dredge, "Elect. Illum.," Vol. I. pp. 46, 91, 95; "New Eng. Mag." for March 1891; Silliman's *Journal*, Vol. XII. p. 69; "Sc. Am. Suppl.," Nos. 198, p. 3148; 206, p. 3284; 526, p. 8404; 547, p. 8733; 652, p. 10416; *La Lum. Electrique* for October 31, 1891, pp. 202–203; Marcel Joubert, "Leçons," 1882, Vol. I. pp. 495, 559, 576; Th. du Moncel, "Exposé des App. de l'Elec.," 1872, Vols. I and II; G. B. Prescott, "Electricity," 1885, Vol. I. pp. 105–112; "Reports of the Smithsonian Institution" for 1857, pp. 372–380; for 1862, p. 204; for 1889, p. 444; Richard Mansill, "New Syst. of Univ. Nat. Science," 1887, pp. 180–185; "Faraday's Researches on Electrostatical Induction," also "Faraday's Law of Attractions and Repulsions," at pp. 26–30, and 647–664 of "Reprint of Papers on Electrostatics and Magnetism," by Sir Wm. Thomson, London, 1884; "Essays in Historical Chemistry," T. E. Thorpe, London, 1894, p. 142; "Life and Letters of Thomas Henry Huxley," by Leonard Huxley, New York, 1901, as per Index at pp. 513–514; "Fragments of Science," by John Tyndall, New York, 1901, Vol. I. pp. 420–443; "Jnl. of Psychological Medicine," by Dr. William A. Hammond, New York, 1870, pp. 555–569; "Cat. Sc. Papers . . . Roy. Soc.," Vol. II. pp. 555–561; Vol. VI. p. 653; Vol. VII. p. 638; "Bibl. Britan.," Vol. XVIII, N.S. for 1821, p. 269; "Phil. Mag. and Jour. of Science," 1833, Vol. III. pp. 18, 37, 38, 161, 253, 353, 460, 469, and Vol. XI, 1838, pp. 206, 358, 426, 430, 538.

APPENDIX I

ACCOUNTS OF EARLY WRITERS, NAVIGATORS AND OTHERS ALLUDED TO BY GILBERT AND NOT ALREADY DISPOSED OF THROUGHOUT THIS "BIBLIOGRAPHICAL HISTORY"

Abano, Pietro di—Petrus Aponus, Apponensis or Apianus—called "the Reconciler" (1250–1316), was Professor of Medicine at Padua and wrote several works of importance on different subjects. The best known is "Conciliator differentiarum philosophorum ac Medicorum," which is devoted to the reconciliation of the various medical and philosophical schools, and in which reference is made to the loadstone, as is also the case in his "Tractatus de Venenis," published during 1490.

References.—Larousse (Pierre), "Dict. Universel," Vol. I. p. 11; "Biographie Générale," Vol. I. pp. 29–31; G. A. Pritzel, "Thesaurus Literaturæ Botanicæ," Lipsiæ, 1851, p. 226; N. F. J. Eloy, "Dict. hist. de la médecine," Mons, 1778, Art. *Apono ;* Ludovico Hain, "Repertorium Bibliographicorum," Art. *Abano ;* Mazzuchelli (Frederigo), "Raccolta d'Opuscoli . . ." Venetia, 1741; Pellechet (Marie), "Catalogue général des incunables," 1897, pp. 1–4; Gilbert, *De Magnete,* Book I. chap. i.

Agricola, Georgius—Bauer—Landmann—(1494–1555), is called by Dr. Thomas Thomson one of the most extraordinary men as well as one of the greatest promoters of chemistry that have ever existed, and he pronounces Agricola's "De Re Metallica," which was published in 1546, 1556, 1558, 1561, as, beyond comparison, the most valuable chemical work produced in the sixteenth century. Agricola is also the author of "De Natura eorum," of "De Natura fossilium" and of "De veteribus et novis metallis," all published at Basle in 1657.

Gilbert mentions Agricola in his *De Magnete* (Book I. chaps. i. ii. vii. viii.; Book II. chap. xxxviii.) and, in connection with him, alludes more particularly to Gilgil, the Mauretanian, and also to Christoph—Entzelt—Encelius, author of a book bearing the same name as Agricola's chief work, "De Re Metallica," published at Frankfort, 1551. Attention may as well be called here to additional authors, whose works, in the same line, are of great variety and

but little known: (1) Cæsalpinus (Andreas) (1519–1603), "De Metallicis," Romæ, 1596; (2) Morieni (Romani), who, in his "De Re Metallica," Parisiis, 1559, treats (as does also John Joachim Beccher, 1635–1682: "Hutton's Abridgments," Vol. I. p. 620) of the transmutation of metals and of the occult, much in same manner as Robertus Vallensis in his "De veritate et antiquitate artis chemicæ . . ." 1593, 1612; (3) Bernardo Pèrez de Vargas, who, in his "De Re Metallica, en el qual se tratan de muchos diversos secretos . . ." Madrid, 1569, tells how to find different kinds of minerals and metals and how to treat them to the best advantage in various industries; (4) J. Charles Faniani, "De Arte Metallicæ," 1576.

Cuvier says of Agricola: "He was the first mineralogist who appeared after the *renaissance* of the sciences in Europe: he was to mineralogy what Conrad Gesner was to zoology."

REFERENCES.—"Biog. Générale," Vol. I. pp. 410–411; Larousse (Pierre), "Dict. Univ.," Vol. I. p. 141; "Dict. hist. de la médecine" (N. F. J. Eloy), Mons, 1778, Vol. I. pp. 50–52.

Agrippa, Heinricus Cornelius—ab Netiesheyem, Nettesheim—(1486–1535), German Doctor of Medicine, also a Doctor of Divinity, a soldier—knighted for valour on the battle-field of Ravenna—a diplomatist, an astrologer, etc. He was in turns, ambassador at Paris and London, historiographer to Emperor Charles V, professor at the university of Pavia, town physician in Friburg, private practitioner at Geneva, court physician to Louise of Savoy, chief magistrate of Metz, theological delegate to the schismatic council of Pisa, etc., and for three years was engaged in a military expedition to Catalonia. He is the author of several important works, the full collection of which was published at Lyons in 1550. The one by which he is best known is "De occulta philosophia," which was translated in French by Levasseur.

REFERENCES.—Morley (Henry), "The Life of H. Corn. Agrippa," London, 1856; Bayle (Pierre), "Dict. Hist."; Jos. Ennemoser, "History of Magic," London, 1854, Vol. II. pp. 253–256; G. Naudé, "Apologie"; Larousse (Pierre), "Dict. Univ.," Vol. I. pp. 143–144; Bolton (H. C.), "Chr. Hist. of Chem.," p. 946; Gilbert, *De Magnete*, Book I. chap. i.

Albategnius—Machometes Aractensis, Muhammad Ibn Jabir—Al-Battani—(*d.* A.D. 929), is considered by Lalande one of the twenty greatest known astronomers. His principal work, "De scientia stellarum," was published in 1537.

REFERENCES.—Delambre (J. B), "Hist. de l'astron. moderne," pp. 10–62; Houzeau et Lancaster, "Bibl. Générale," Vol. I. part. i. p. 467; Vol. II. p. 71; Gilbert, *De Magnete*, Book VI. chap. ix.; "Engl. Cycl.," Vol. I. p. 84.

Alexander Aphrodisæus — Aphrodisiensis — a celebrated Greek scientist and the oldest commentator on Aristotle, who lived at about the close of the second century after Christ, and whose works were so highly esteemed by the Arabs that they translated most of them (Casiri, " Bibl. Arab. Hisp. Escur.," Vol. I). The list of all of his publications appears in " Biog. Générale," Vol. I. pp. 911–914.

References.—Fabricius (Johann Albert), " Bibliotheca Græca," Vol. V. p. 650; Ritter (Dr. Heinrich), " Geschichte der Philosophie," Vol. IV. p. 24; Gilbert, *De Magnete*, Book I. chap. i. and Book II. chaps. ii. xxv.

Amatus Lusitanus. *See* Lusitanus Amatus.

Anaxagoras, born at Clazomenæ, one of the Greek towns of Ionia, in 500 B.C., three years before the death of Pythagoras, was a very eminent philosopher of the Ionic school, wherein he succeeded Anaximenes as a leader, and numbered among his many hearers and pupils Diogenes of Apollonia, Pericles, Euripides, Socrates and Archelaus. A very good analysis of Anaxagoras' philosophical opinions is to be found in the " Biographical Dictionary of the Society of Useful Knowledge." Gilbert alludes to him (*De Magnete*, Book II. chap. iii. and Book V. chap. xiii.) as believing that the loadstone was endowed with a sort of life, because it possessed the power of moving and attracting iron, and as declaring in fact that the entire world is endowed with a soul.

Anaxagoras is accused, by Pliny and other early writers, of having predicted the fall of aerolites from the sun, and of regarding all bodies in the universe " as fragments of rocks, which the fiery ether, in the force of its gyratory motion, has torn from the earth and converted into stars " (Humboldt, " Cosmos," 1859–1860, Vol. I. pp. 133–135, note; Vol. II. p. 309; Vol. III. pp. 11–12; Vol. IV. pp. 206–207).

Aristotle also attacks Anaxagoras for not properly etymologizing the word *aether*, from *αἴθειν*, to burn, and on this account using it for fire. He shows that *aether*, which signifies to run perpetually, implies that a perpetual motion and perpetuity of subsistence belongs to the heavenly bodies (" Treatises of Aristotle," by Thos. Taylor, London, 1807, p. 43, note).

According to Anaximenes, named above (born at Miletus about 528 B.C.), the primal principle was Aer, of which all things are formed and into which all things are resolved. He belonged to the branch called the dynamical, whose doctrines as to the heavenly bodies were opposed to those of mechanical philosophers such as Anaxagoras, Empedocles and Anaximander of Miletus (" Engl. Cycl.," Biography, 1866, Vol. I. p. 201).

References.—Houzeau et Lancaster, "Bibl. Gén.," Vol. I. part i. pp. 401–402, and Vol. II. p. 74; "Plato," by George Grote, London, 1865, Vol. I. pp. 49–62; "Essai théorique et pratique sur la génération des connaissances humaines," par Guillaume Tiberghien, Bruxelles, 1844, Vol. I. pp. 181–182; Dr. Heinrich Ritter, "History of Ancient Philosophy," London, 1846, Vol. I. pp. 281–318; Chas. Rollin, "Ancient History," London, 1845, Vol. I. p. 376; Paul Tannery, "Pour l'histoire de la Science Hellène," Paris, 1887, Chap. XII; Theod. Gomperz, "Greek Thinkers," transl. of L. Magnus, London, 1901, Chap. IV. pp. 556–558, 597; Ueberweg, "Hist. of Philosophy," transl. of Geo. S. Morris, New York, 1885, Vol. I. pp. 63–67; Alf. Weber, "Hist. of Phil.," transl. of Frank Thilly, New York, 1896, pp. 48–53.

Aquinas—St. Thomas—also called Doctor Angelicus (born at Aquino in Naples, A.D. 1225)—"the most successful organizer of knowledge the world has known since Aristotle"—was a famous schoolman and is considered by many the greatest of Christian philosophers. He is well worthy the profound respect and high admiration in which he is held always by Gilbert, who alludes to him in Book I. chap. i. and in Book II. chap. iii. of his *De Magnete*. The chief work of St. Thomas Aquinas is the "Summa Theologiæ," to which he devoted the last nine years of his life and which by many has been called the supreme monument of the thirteenth century. The first part of the "Summa Theologiæ" is said to have been originally published in 1465 and the second part in 1471, the completed work first appearing during the year 1485.[1]

One of his critics remarks that those wishing to thoroughly comprehend the peculiar character of metaphysical thought in the Middle Ages should study Aquinas, in whose writings it is seen with the greatest consistency. He is thus spoken of in Dr. Wm. Turner's "History of Philosophy," published by Ginn & Co., 1903: "He had a comprehensiveness of purpose which, in these modern times, seems nothing short of stupendous. It is only when, as we study the history of later scholasticism and the history of the philosophy of modern times, we shall look back to the thirteenth century through the perspective of ages of less successful attempts at philosophical synthesis, that we shall begin to realize the true grandeur of the most commanding figure in the history of mediæval thought."

[1] In the Summa of Theology was presented, says Ozanam Antoine Frédéric, a vast synthesis of the moral sciences, in which was unfolded all that could be known of God, of man and of their mutual relations—a truly Catholic philosophy. . . . Sixtus of Sienna and Trithemius both declare that St. Thomas explained *all* the works of Aristotle and that he was the first Latin Doctor who did so ("Christian Schools and Scholars," p. 81).

It may also be added that, in the estimation of one of his biographers, the greatest of the many disciples of St. Thomas was, by far, Dante Alighieri, in whose "Divina Commedia" the theology and philosophy of the Middle Ages, as fixed by St. Thomas, have received the immortality which poetry alone can bestow.

Aquinas died at the Cistercian Monastery in 1274, and was canonized forty-nine years later by Pope John XXII.

References.—Carle (P. J.), "Hist. de la vie . . . de Th. d'Aq.," 1846; Maffei (Francesco Scipione), "Vita . . ." 1842; B. Hauréau, "De la Phil. Schol.," Paris, 1850, Vol. II. pp. 104, 213; G. Tiberghien, "Essai historique . . . des con. hum.," Bruxelles, 1844, Vol. I. pp. 374–378; Dr. Fried. Ueberweg, "Hist. of Phil.," transl. of Geo. S. Morris, New York, 1885, Vol. I. pp. 440–452; "Thomæ Aquinatis Opera Theologica," Venice, 1745–1760, 28 vols. quarto, edited by Bernardo M. de Rossi-Rubeis; "Petri de Bergamo, Super Omnia Opera D. Thomæ Aquinatis," Bononiæ, 1473; "Biogr. Gén.," Vol. XLV. pp. 208–218; "Siger de Brabant et l'Averroïsme au 13e siècle," par Pierre Maudonnet, Friburg, 1899, Chap. IV *passim*; "Albert the Great," by Dr. Joachim Sighart, transl. of Rev. Fr. T. A. Dixon, London, 1876, Chap. VI. p. 63; "The Great Schoolmen of the Middle Ages," by W. J. Townsend, London, 1881, pp. 199–241; Alfred Weber, "Hist of Phil.," transl. of Frank Thilly, New York, 1896, pp. 241–246; Dr. W. Windelband, "Hist. of Phil.," authorized transl. by Jas. H. Tufts, New York, 1893, pp. 313–314; Paola Antonia (Novelli), "De D. Th. Aquin."; A. Hunaci, "Oratio," Venice, 1507; likewise Veen (Otto van), Etiro (Partenio), Rodericus de Arriaga, Frigerio (Paolo) and Thouron (V. C.) in their works on Aquinas, 1610, 1630, 1648, 1688 and 1737–1740; Henry Hart Milman, "History of Latin Christianity," London, 1857, Vol. VI. pp. 273–278, 281–286; Pellechet (Marie), "Catal. Gén. des Incunables," 1897, pp. 210–249; Houzeau et Lancaster, "Bibl. Gén.," Vol. II. p. 264; "Le Journal des Savants" for May 1851, pp. 278, 281–298 *passim*, and also in the issue of December 1905.

Aristarchus of Samos, one of the earliest astronomers of the Alexandrian School, who lived in the third century B.C., is referred to in Gilbert's *De Magnete*, at Chaps. III and IX of book vi. Vitruvius ascribes to him the invention of a concave sundial which he calls *scaphe* and which is described by Martianus Mineus Capella (cited by Weidler); and Censorinus says that Aristarchus was the author of an extensive work called "Annus Magnus," covering a period of 2484 years.

References.—Larousse, "Dict. Univ.," Vol. I. p. 623; Montucla (J. F.), "Hist. des Math.," Vol. I. p. 721; Houzeau et Lancaster, "Bibl. Gén.," Vol. II. p. 77; "Engl. Cycl.," Vol. I. p. 314.

Arnaldus de Villa Nova—Arnaldus Novicomensis—Arnaud de Villeneuve, dit de Bachuone (1235–1312), who assumed the name of Magrinus when on his way from France to Sicily, was an eminent physician, the master of Raymond Lully, who taught medicine as well as alchemy at Barcelona and whose numerous treatises upon the virtues of plants, etc., are analyzed in M. F. Hœfer's "Histoire de la Chimie," Vol. I. p. 385. The first edition of his works appeared at Lyons in 1504.

References.—Campegius (Laurentius), "Arnaldi Vita"; "Nouvelle Biographie Générale" (Hœfer), Vol. III. pp. 279–282; Boulay (H. de), "Hist. de l'Univ. de Padoue," Vol. IV; Freind (John), "Hist. de la Médecine," Vol. III; N. F. J. Eloy, "Dict. Hist. de la Médecine,"

Mons, 1778, Tome III. p. 131; Astruc (Jean), "Hist. de la fac. de méd. de Montpellier"; "Journal des Savants" for June 1896, p. 342, "Testaments d'Amand de Villeneuve et de Raimond Lulle," "L'Alchimie et les Alchimistes"; Figuier (Louis), Paris, 1860, p. 172; Gilbert, *De Magnete*, Book I. chap. i.

Barbarus, Hermolaus—Barbaro Ermoleo—(1454–1495)—(Barbari Hermolai, Aquileiensis Pontificis), whose name alone Gilbert mentions, was a well-known Italian savant, Professor of Philosophy at the Padua University, and the author of many works, of which the most popular are: (1) "Castigationes Plinianæ," Rome, 1492, wherein he boasts of having made more than five thousand corrections in Pliny's "Natural History"; (2) "Castigationes Secundæ," Venice, 1480; (3) "Castigationes in Pomponium Melam," Antwerp, 1582; (4) "Compendium scientiæ naturalis ex Aristotele," Venice, 1545.

References.—Paul Jove, "Elogia"; Boissardus (Joannes Jacobus), "Icones . . . virorum illustrium"; "Giornale de' letterati d' Italia," Vol. XXXVIII; "Theosaurus Litteraturæ Botanicæ," Lipsiæ, 1851, p. 333; "Biogr. Générale," Vol. IV. pp. 418–419.

Becanus. *See* Goropius.

Benedictus—Benedetti—Joannes Baptista (1530–1590), Italian mathematician, who was considered a prodigy at the age of eighteen, and who, five years later, published in Venice a remarkable work on the solution of most of Euclid's problems. He is also the author of treatises on navigation, astronomy, music, etc., and can justly be placed in the first rank of savants of the sixteenth century.

References.—"La Grande Encyclopédie," Vol. VI. pp. 132–133; "Biog. Générale," Vol. V. pp. 340–342; Libri (Guillaume), "Hist. des Sciences Mathém," Vol. III. pp. 121–133; Montucla (J. F.), "Hist. des Mathém.," Vol. I. pp. 572, 693, 729; Marie (J. F.), "Hist. des Sc. Math.," Vol. II. p. 307; Houzeau et Lancaster, "Bibliographie Générale," Vol. II. p. 83; Gilbert, *De Magnete*, Chap. IX of book iv.

Brasavolus, Antonius Musæ (1500–1570), alluded to by Gilbert in Book I. chap. i., was a very eminent Italian physician and the author of "Examen omnium simplicium medicamentorum," Rome, 1536, as well as of "In octo libros Aphorism. Hippocratis Comment. et Annot.," Basle, 1541, and of several other works, including a very complete index of all the notable features of the works of Galen.

References.—Ginguené (Pierre Louis), "Histoire Litéraire d' Italie"; Baruffaldi (Girolamo), "Commentario istorico all' inserizione . . ." Ferrara, 1704; "Biog. Générale," Vol. VII. p. 269; "Storia della Medicina in Italia" (Salvatore de Renzi), Napoli, 1848, in Vol. III *passim* as per Index, Vol. V. p. 987; Pritzel (G. A.), "Thesaur. Lit. Botan.," 1851, p. 31.

Calaber, Hannibal Rosetius. Of all the authors cited by Gilbert, this is the only one, who, thus far, cannot satisfactorily be identified, although exhaustive efforts to this end have been made by the authors of both the English translations of *De Magnete.* One interpretation (Hannibal, of Roseto in Calabria, shown on map at end of Vol. I. of " Briefe uber Kalabrien und Sizilien," Göttingen, 1791), has as yet found no endorsement.

Calcagninus, Cælius, Italian philosopher and astronomer (1479–1541) is the author of " Quomodo Cœlum stet, terra moveatur . . ." wherein he asserts that the earth turns around the sun, also of " De Re Nautica," containing a good account of ancient ceremonies and observations, as well as of a Commentary on Aristotle, and of many creditable poetical effusions published 1533. His complete works appeared at Basle during the year 1544, and a list of them, fifty-six in all, is given by Jean Pierre Nicéron in his " Mémoires pour servir à l'histoire des hommes illustres," Paris, 1727–1745.

References.—Calcagnini (T. G.), " Della vita . . . C. Calcag "; Ginguené (Pierre Louis), " Histoire Litéraire d' Italie," Vols. IV, VI and VII; Paul Jove—Jovius—Giovio (*b.* 1483, *d.* 1552), " Eloges "; Borsetti, Ferranti Bolani (Ferrante Giovanni), " Historia almi Ferrariæ Gymnasii," 1735; " Biog. Gén.," Vol. VIII. pp. 159–161; Larousse, " Dict. Univ.," Vol. III. p. 109; Houzeau et Lancaster, " Bibl. Gén.," Vol. II. p. 98; Gilbert, *De Magnete,* Book I. chap. i.

Cardanus, Hieronymus (1501–1576), who is so very frequently mentioned by Gilbert, throughout Books I, II, III and IV, was an Italian physicist whose writings are extremely numerous and are well reviewed in the best edition of his works published at Lyons during 1663. Those by which he is best known are the " Ars Magna," " De Rerum Varietate, Libri XVII," and the " De Subtilitate, Libri XXI," which may be considered the exponent of all his scientific knowledge and a notably good translation of which, in French, by Richard Leblanc was published in Paris, 1556.

References.—Morley (H.), " Life of Cardan," 1854, wherein, Vol. II. pp. 56–70, will be found a long account more particularly of the contents of " De Subtilitate "; Larousse, " Dict. Univ.," Vol. III. pp. 376–377; Dr. Fr. Ueberweg, " Hist. of Philosophy," tr. of Geo. S. Morris, 1885, Vol. II. p. 25; Walton and Cotton, " Complete Angler," New York and London, 1847, Part I. p. 142; Houzeau et Lancaster, " Bibl. Gén.," Vol. II. p. 101.

Copernicus, Nicolaus — Koppernik — Zepernic — celebrated astronomer, native of Poland (1472–1543), whose studies led him to reject the Ptolemaic system of the universe, and who proposed the one now bearing his name, is the author of " De revolutionibus orbium cœlestium," which was published May 24, 1543, a few days before his death. He is alluded to by Gilbert (*De Magnete,* Chaps.

II, III, VI, IX, of book vi.), who calls him "the restorer of astronomy" and "a man most worthy of the praise of scholarship." The life and labours of Copernicus are fully detailed, in chapter treating of "Discoveries in the celestial spaces" of the "Cosmos," by Von Humboldt, who, in relation to a passage in "De Revolutionibus," makes the following very curious note: "It very singularly happens that in an otherwise instructive memoir" (Czynski, "Kopernik et ses travaux," 1847, p. 102), "the *Electra* of Sophocles is confounded with electric currents. The passage of Copernicus (quoted in Latin) is thus rendered: 'If we take the sun for the torch of the universe, for its spirit and its guide—if Trismegistes call it a God, and if Sophocles consider it to be an electrical power which animates and contemplates all that is contained in creation . . . .'

"Four men, Gutenberg, Columbus, Luther and Copernicus, stand at the dividing line of the Middle Ages, and serve as boundary stones marking the entrance of mankind into a higher and finer epoch of its development" (Kapp (Friedrich), *Geschichte*, etc., I).

REFERENCES.—Westphal (E. J.), "Nikolaus Kopernikus" ("Biographie des Copernicus"); Delambre (J. B. J.), "Histoire de l'astronomie Moderne"; "Journal des Savants" for February 1864 and for December 1895; Larousse, "Dict. Univ.," Vol. V. pp. 66–67; Edw. S. Holden in "Pop. Sc. Monthly" for June 1904, pp. 109–131; *Phil. Magazine*, Vol. XIX. p. 302; Gassendi (Pierre), in "Nicolai Copernici Vita," appended to his biography of Tycho ("Tychonis Brahei Vita," 1655, Hagæ Comitum, p. 320); W. Whewell, "Hist. of the Ind. Sciences," New York, 1858, Vol. I. pp. 257–290; the article at pp. 378–382, "Engl. Cycl.," which abounds in references; Rheticus, "Narrat. prima"; Kepler (Johann), "De Temporis"; Horrebow (at A.D. 1725—the luminous process of the sun, a perpetual northern light); Houzeau et Lancaster, "Bibl. Gén.," Vol. II. pp. 109–113, for an extended list of authorities, and also pp. 1571–1572; Joachimus (Georgius) surnamed Rhecticus, who quotes many works on Copernicus.

Cordus, Valerius—Eberwein—celebrated German botanist (1515–1544), who is alluded to by Gilbert, Book I. chap ii. wrote a Commentary on Dioscorides, published by Egénolphe in 1549, as well as an extensive history of plants, which is to be found in the Strasburg editions of his works, issued during 1562 and 1569.

REFERENCES.—"Biog. Générale" (Hœfer), Vol. XI. pp. 804–807; Larousse (Pierre), "Grand Dictionnaire Universel," Vol. V. p. 133; Adam (Melchior), "Vitæ med. Germ."; "Lindenius renovatus"—"Thesaur. Lit. Botan.," 1851, pp. 52, 334; Camerarius, "Vita Melanchton"; Linden (Joannes Antonides van der), "De Scriptis Medicis," 1651, pp. 572–573; "Dict. Historique de la Médecine," par N. F. J. Eloy, Mons, 1778, pp. 705–707, Vol. I.

Cortesius, Martinus, celebrated Spanish geographer who died about 1580, is the author of the well-known and extremely scarce work, "Breve compendio de la esfera, y de la arte de navegar," Cadiz, 1546 1551, and Seville, 1556, which was translated by

Richard Eden, 1561, 1589, 1609. Of the 1556 issue, Salva remarks (II, 3763): "2e édition aussi rare que la première. C'est cet ouvrage qui a revolutionné la science nautique et qui fut le premier à indiquer la déclinaison de l'aiguille. Les instructions pour construire des mappemondes ne sont la partie la moins intéressante du texte et pourraient être utiles à tous ceux qui sont incapables de comprendre le principe des roses de vents et des loxodromes, qui couvrent la surface des cartes hydrographiques anciennes. Mais c'est justement ici que l'intelligence pénétrante de Cortez a indiqué les défauts de la projection longtemps avant Mercator."

For a reproduction of the title page and of the twelve-page text of Martin Cortez's "Breve Compendio," see G. Hellmann, "Neudrucke," 1898, No. 10.

References.—Fernandez de Navarrete, "Disertacion sobre la historia de la nautica y de las mathematicas," Madrid, 1846; "La Grande Encyclopédie," Vol. XII. p. 1114; "Biographie Générale," Vol. XI. p. 964; Gilbert, *De Magnete*, Book I. chap. i.; Book III. chap. i. and Book IV. chap. i.

Costæus, Joannes—Giovanni Costeo—of Lodi, who died at Bologna in 1603, was an Italian physician teaching medicine at the Universities of Turin and of Bologna and the author of several valuable works, notably the "Tractatus de universali stirpium natura," Turin, 1578; the "Disquisitionum physiol. . . . Avicennæ sectionem," Bologna, 1589; the "Annot. in Avicennæ canonem . . ." Venetia, 1595; and the "De igneis medicinæ . . ." published also at Venice in the last-named year.

Gilbert, who speaks of him (*De Magnete*, Book I. chap. i.; Book II. chap. iii.; Book VI. chap. v.) gives this as the theory propounded by Costæus regarding the powers of amber and loadstone: "There is work on both sides, result on both sides, and therefore the motion is produced in part by the loadstone's attraction and in part by the iron's spontaneous movement; for, as we say that the vapours given out by the loadstone do by their own nature haste to attract the iron, so, too, do we say that the air impelled by the vapours, while seeking a place for itself, is turned back, and when turned back impels and transfers the iron, which is picked up, as it were, by it, and which, besides, is exerted on its own account. In this way, there is found a certain composite movement, resulting from the attraction, the spontaneous motion and the impulsion; which composite motion, however, is rightly to be referred to attraction, because the beginning of this motion is invariably from one term, and its end is there too; and that is precisely the distinguishing character of attraction."

References.—Eloy (N. F. J.), "Dict. historique de la Médecine"; Larousse, "Dict. Univ.," Vol. V. p. 245.

Cusanus—Nicolas Khrypffs or Krebs, Cardinal de Cusa (1401–1464), an eminent German scholar, who, abandoning the study of law, entered the Church, became Archdeacon of Liége, member of the Council of Basle, and was raised, in 1448, to the dignity of Cardinal. His biographer in the ninth "Encycl. Britan." (Vol. VI. pp. 728–729) says: "As in religion he is entitled to be called one of the *Reformers before the Reformation*, so, in philosophy, he was one of those who broke with scholasticism while it was still the orthodox system." His works were published in complete form by H. Petri, 1565.

References.—Hartzheim (Josephus), "Vita N. de C.," Trèves, 1730; Deux (M.), "Life of C. Cusa," 1847; Scharpff (Franz Anton), "Der Cardinal und Bischof Nic. von Cusa . . ." Tübingen, 1871; Dr. W. Windelband, "History of Philosophy," auth. tr. by Jas. H. Tufts, New York, 1893, pp. 345–347; Humboldt, "Cosmos," 1860, Vol. II; Libri (G.), "Hist. des Sciences Mathém.," Vol. III. p. 99; Dr. F. Ueberweg, "History of Philosophy," tr. by Geo. S. Morris, 1885, Vol. II. pp. 23–24; Ritter (Dr. Heinrich), "Geschichte der Phil.," Vol. IX. p. 142; Gilbert, *De Magnete*, Book I. chap. i. and Book II. chaps. iii. xxxvi.; "Journal des Savants" for January 1894; Houzeau et Lancaster, "Bibl. Gén.," Vol. II. p. 115; Larousse, "Dict. Univ.," Vol. V. p. 687; "Biogr. Gén.," Vol. XII. pp. 651–657.

Dominicus, Maria Ferrariensis—"Novara"—Italian savant (1464–1514), taught astronomy at Bologna, Rome and elsewhere, and had for one of his pupils the celebrated Copernicus, who, later on, became an associate in his investigations. None of his writings have reached us.

Gilbert thus alludes to Dominicus as well as to Stadius at Chap. II. book vi. of his *De Magnete*: "According to Dominicus Maria's observations, the north pole is raised higher and the latitudes of places are greater now than in the past: from this he infers a change of latitudes. But Stadius, holding the directly opposite opinion, proves by observations, that the latitudes have grown less. 'The latitude of Rome,' says he, 'is given in the *Geographia* of Ptolemy as $41\frac{2}{3}°$; and lest any one should say that some error has crept into the text of Ptolemy, Pliny relates, and Vitruvius in his ninth book testifies, that at Rome on the day of the equinox the ninth part of the gnomon's shadow is lacking. But recent observation (as Erasmus Rheinhold states) gives the latitude of Rome in our age as $41\frac{1}{6}°$; so that you are in doubt whether one-half of a degree has been lost (*decrevisse*) in the centre of the world, or whether it is the result of an obliquation of the earth.'"

References.—Borsetti (Ferrante Giovanni), "Hist. Gymn. Ferrar.," Vol. II. p. 50; Tiraboschi (Girolamo), "Storia della Letteratura Italiana," Vol. XIV. p. 296; Montucla (J. F.), "Hist. des Math.," Vol. I. p. 549; Houzeau et Lancaster, "Bibl. Gén.," Vol. II. pp. 215–216; "Biog. Gén.," Vol. XXXVIII. p. 336.

Dupuis. *See* Putaneus.

Empedocles, whom Gilbert merely names in Book V. chap. xii. of *De Magnete,* was a native of Sicily, distinguished as a philosopher as well as for his knowledge of medicine and of natural history.

Empedocles flourished about the year 442 or 460 B.C., and was pupil of Pythagoras or Anaxagoras, and, as others say, of Parmenides ("The Metaphysics of Aristotle," by the Rev. John H. McMahon, London, 1857, pp. 19–20, 34, 118).

"Rien n'est engendré, disait Empédocle, rien ne périt de la mort funeste. Il n'y a que mélange ou séparation de parties. . . . L'éclair, c'est le feu s'échappant du nuage où le soleil l'avait lancé. La foudre n'est qu'une plus grande quantité de feu. Le tonnerre, c'est ce même feu qui s'éteint dans le nuage humide. . . . Les phénomènes magnétiques viennent de la convenance parfaite des pores et des effluves de l'aimant et du fer. Dès que les effluves de l'aimant ont chassé l'air que contenaient les pores du fer, le courant des effluves de fer devient si fort que la masse entière est entrainée" ("Dict. des Sc. Philos.," Paris, 1852, Vol. II. pp. 206–214).

References.—Karsten, "Emped. Agrig. Carmin. Reliq." in Vol. II of "Phil. Graec. vet. relig.," Amst., 1838; and the extensive list of authorities cited in Larousse, "Dict. Univ.," Vol. VII. pp. 457–458; Houzeau et Lancaster, "Bibl. Gén.," Vol. I. part i. p. 401; Ueberweg, "Hist. of Philos." (Morris), 1885, Vol. I. pp. 60–63; "The Works of George Berkeley," by A. C. Fraser, Oxford, 1901, Vol. III. pp. 205, 247, 254, 290; Paul Tannery, "Pour l'histoire de la Science Hellène," Paris, 1887, Chap. XIII. pp. 304–339; "Greek Thinkers," by Theodor Gomperz, tr. of L. Magnus, London, 1901, Chap. V. pp. 558–562, 601; "A History of Classical Greek Literature," by Rev. John P. Mahaffy, New York, 1880, Vol. I. pp. 123–128; Vol. II. pp. 48, 73, 77; "Essai Théorique et Historique sur la génération des connaissances humaines," par Guillaume Tiberghien, Bruxelles, 1844, Vol. I. pp. 185–187.

We are told by Alex. Aphr. (Quæst. Nat., II. 23, p. 137, Speng) that, like Empedocles, Democritus sought to explain the attractive power of the magnet, upon which the latter wrote a treatise (according to Diog. IX. 47).

Democritus was born at Abdera in Thrace about 470 or 460 B.C., and, according to Thrasyllus, the grammarian, he died 357 B.C.—the same year as Hippocrates. He was considered, by far, the most learned thinker of his age, and, according to Carl Snyder, who dedicates "The World Machine," 1907, to Democritus, he was justly esteemed by Bacon as the mightiest of the ancients, for he wrote illuminatively upon almost every branch of natural knowledge.

The following note to "The Atomistic Philosophy" appears at p. 230, Vol. II of Dr. E. Zeller's "History of Greek Philosophy," translation of S. F. Alleyne, London, 1881 :

" Leucippus and Democritus derive all action and suffering from contact. One thing suffers from another, if parts of the latter penetrate the empty interspaces of the former. . . . Democritus thought that the magnet and the iron consist of atoms of similar nature but which are less closely packed together in the magnet. As, on the one hand, like draws like, and, on the other, all moves in the Void, the emanations of the magnet penetrate the iron, and pass out a part of its atoms, which, on their side, strain towards the magnet, and penetrate its empty interspaces. The iron itself follows this movement, while the magnet does not move towards the iron, because the iron has fewer spaces for receiving the effluences."

The attraction of the magnet, as explained by Diogenes of Appolonia, is thus given by Alex. Aphr. (Quæst. Nat., II. 23, p. 138, Speng) : " Empedocles supposed that, after the emanations of the magnet have penetrated into the pores of the iron, and the air which choked them has been expelled, powerful emanations from the iron pass into the symmetrical pores of the magnet, which draw the iron to itself and hold it fast."

It may be added that the Atomic Doctrine of Leucippus and Democritus was opposed to the Homoiomeria of Anaxagoras of Clazomenæ—the last great philosopher of the Ionian School.

References.—Ueberweg (Fr.), " History of Philosophy," trans. of G. S. Morris, New York, 1885, Vol. I. pp. 67–71; Larousse (Pierre), " Dict. Univ. du XIXe siècle," Paris, 1870, Tome VI. pp. 409–410; " La Grande Encyclopédie," Paris, Tome XIV. pp. 66–69; " Nouvelle Biographie Générale " (Hœfer), Paris, 1855, Vol. XIII. pp. 566–574; Franck (Ad.), " Fragments qui subsistent de Démocrite," in the " Mém. de la Société Royale de Nancy," 1836; Beazley (C. Raymond), " The Dawn of Modern Geography," Oxford, 1906, Vol. I. p. 254 (the use by Democritus of magnetic stones, mentioned by Solinus); Snyder (Carl), " The World Machine," 1907, p. 133 (work on the magnet); Zeller (Eduard), " Philosophie der Griechen "; Ritter and Preller, " Historia Philosophiæ Græcæ " (7th ed., Gotha, 1888); Mulloch (F. G. A.), " Democriti Abderitæ operum fragmenta," Berlin, 1843.

Erasmus, Reinholdus (1511–1553), a German savant, who taught astronomy and mathematics at Wittemberg, has left us " Commentarius Theoricæ Novæ Planetarum," 1542, 1558, a work which, Delambre says, supplies the omissions of Purbacchius and must have cleared many of the passages of Ptolemy's syntax. He also wrote " Almageste," 1549;[1] made up the Prutenic (Prussian)

[1] Almagest was the name given to the great work of Aboulwéfa and was afterwards often applied to astronomical writings treating of celestial phenomena in general. The word is of Greek, not Arabic, origin, and signifies a composition made up on a very extensive scale (" Journ. des Savants," December 1843, p. 725, and March 1845, p. 150). Almagest was also the name given to the extensive astronomical work by Ptolemy of Alexandria, which established the Ptolemaic System as astronomical science for 1400 years, until overthrown by the system of Copernicus. Ptolemy's work

astronomical tables ("Prutenicæ tabulæ cœlestium motuum," 1551), from the observations of Copernicus, Hipparchus and Ptolemy, and he is believed to be the author of the anonymous work entitled "Hypotyposes orbium cœlestium. . ." which appeared during the year 1568.

Gilbert's reference to Erasmus has already been given in connection with Dominicus.

References.—Vossius (G.), "De Scientiis Mathem.," Chap. XXXVI. p. 14; Delambre (J. B. J.), "Hist. de l'astronomie moderne," Vol. I. pp. 142, 146, 164; Zedler (Johann Hch.); Mädler—Mædler (Johann Henrich von), Vol. I. p. 168; Bailly (Jean Sylvain), "Histoire de l'astronomie moderne . . ." Vol. I. p. 366 and Vol. II. p. 71; Jöcher (Johann Friedrich), "Bibliogr. Astronom."; Weidler (Christian Gottlieb), p. 353; "Biogr. Générale," Vol. XLI. pp. 928–929.

Erastus, Thomas—Thomas Lieber—(1524–1583) was a native of Switzerland, notable in medicine and famous in ecclesiastical polemics, who furiously combated the medical views of Paracelsus, notably in his "Disputationum de Medicina," Basileæ, 1572–1573. Gilbert mentions him (*De Magnete,* Book I. chaps. i. and vii.), merely saying that, knowing naught of the nature of the loadstone, Erastus draws from it weak arguments against Paracelsus.

His numerous works are detailed in the "Biographisches Lexikon," Vienna und Leipzig, 1885, Vol. II. pp. 292, etc., and a very complete account thereof is to be found at pp. 561–564 of "De Scriptis Medicis," by Joannes Antonides Van Der Linden, Amstel., 1651.

References.—Pluquet (François André Adrien), "Diction. des Hérésies"; Moreri (Louis), "Le Grand Dictionnaire Historique"; Wordsworth (Christopher), "Ecclesiastical Biography"; "New Int. Encycl.," New York, 1903, Vol. VI. p. 828; "Biog. Gén.," Vol. XXXI. pp. 174–175; "La Grande Encyclopédie," Vol. XVI. p. 163; Larousse, "Dict. Univ.," Vol. VII. p. 788; Adam (Melchior), "Vitæ Germanorum Medicorum," pp. 107–109; Bolton, H. C., "Ch. Hist. of Chem.," p. 981.

Evax—Euace—a Latin naturalist who lived in the time of Tiberius and said to have been King of the Arabs, is the supposed author of "De nominibus et virtutis lapidum qui in artem medicinæ recipiuntur," treating of gems, of which the MS.—now in the Oxford Library—was used by Marbodeus to make up his own work on precious stones.

Salmasius delivers it as his opinion that, by an error of transcribers, from Cratevas, who in some copies is also named

(originally entitled "The Great Composition"), the Arabs called by the Greek word *magistê,* "greatest," and, with the addition by Arabic translators of their article *al,* "the," the hybrid name "Almagest" came into use ("Encycl. Amer.," Vol. I. n. p.; "Encycl. Britan.," Edin., 1886, Vol. XX).

Cratevas, this Evax has arisen. ("Gen. Biog. Dict." of Alex. Chalmers, London, 1814, Vol. XIII. p. 411.)

References.—"Journal des Savants" for June 1891 ("Traditions . . . chez les Alchimistes du Moyen Age," par Marcellin Pierre Eugène Berthelot); Larousse, "Dict. Univ.," Vol. VII. p. 1153; Gilbert, *De Magnete*, Book II. chap. xxxviii.

Fallopius, Gabriellus (1523–1562), was a famous Italian anatomist and one of the three who, according to Cuvier, restored or rather created anatomy during the sixteenth century. The other two were Vassalli and Eustachi. His principal work is "Observationes Anatomicæ," Venice, 1561; a list of the others—named in "Biog. Gén.," Vol. XVII. pp. 66–69—embracing "De medicatis . . . de metallis sev fossilibus . . ." Venice, 1564; "De Simplicibus Medicamentis purgantibus tractatus," 1566; "De Compositione Medicamentorum," 1570; "Opera Genuina Omnia," 1584, 1596, 1606. The collected edition of his complete works was published in Venice, 1584, and at Frankfort, 1600.

References.—Tiraboschi (Girolamo), "Biblioteca Modencse," Vol. II. p. 236; Nicéron (J. P.), "Mémoires," Vol. IV. p. 396; Gilbert, *De Magnete*, Book I. chaps. i. and xv. also Book II. chap. xxxviii.; Larousse, "Dict. Univ.," Vol. VIII. p. 67.

Fernelius, Joannes Franciscus (1497–1558), celebrated French physician, called the modern Galen, is the author of many works which are cited at pp. 477–483, Vol. XVII of the "Biographie Générale," the principal ones being "De naturali parte medicinæ," 1542, "De vacuandi ratione liber," 1545, and "De Abditis Rerum Causis," 1548. Gilbert alludes to the last named (*De Magnete*, Book I. chap. i.), saying that Fernel believes there is in the loadstone a hidden and abstruse cause: elsewhere he says this cause is celestial; and he does but explain the unknown by the more unknown. This search after hidden causes, he adds, is something ignorant, beggarly and resultless.

References.—Thou (François Auguste de), "Historiarum sui temporis"; Sc. de Sainte Marthe, "Elogia Doct. Gallorum"; Eloy, "Dict. Hist. de la Médecine," Mons, 1778, Vol. II. pp. 208–221; Larousse, "Dict. Univ.," Vol. VIII. p. 259.

Ficino, Marsilia (1433–1499), was the son of Ficino, the physician of Cosmo de Medici, and was one of the leading scholars of the Renaissance. He was celebrated as the most distinguished translator of Plato and as the reviver of Platonic philosophy in Italy. One of his biographers has said that the most important feature of his philosophy is his claim to harmonizing Platonic idealism with Christian doctrine.

Gilbert says that "Ficinus chews the cud of ancient opinions, and to give the reason of the magnetic direction seeks its cause in the constellation Ursa. Ficinus writes, and Merula copies, that in the loadstone the potency of Ursa prevails, and hence it is transferred into the iron" (*De Magnete*, Book. I. chap. i.; Book III., chap. i.; Book IV. chap. i.).

His complete works (published in two volumes, Venice, 1516, Basle, 1561, 1576, Paris, 1641), embrace "Theologiæ Platonicæ," 1488; "De Vita libri tres," 1489; "Iamblichus, de mysteriis . . ." 1497; "Apologiæ in qua medicina, astrologia . . ." 1498.

References.—Corsi (Raimondo Maria), "M. Ficini Vita," Pisa, 1772; Symonds (John Addington), "Remains in Italy," London, 1875, and "Renaissance in Italy," New York, 1888, pp. 324–328; "English Cyclop." (Biography), Vol. II. p. 908; "The Rise of Intellectual Liberty from Thales to Copernicus," by Frederic May Holland, New York, 1885, pp. 279–280; Larousse, "Dict. Univ.," Vol. VIII. pp. 331–332; "Journal des Savants" for May 1894; Houzeau et Lancaster, "Bibl. Gén.," Vol. II. p. 131; "Biog. Générale," Vol. XVII. pp. 634–638; "The Works of Geo. Berkeley," by A. C. Fraser, Oxford, 1901, Vols. II. p. 268; III. pp. 216–217, 221–223, 260, 296–297; "Dict. of Philos. and Psych.," by J. M. Baldwin, New York, 1901, Vol. I. p. 381.

Fracastorio, Hieronymo (1483–1553), Italian physician and one of the most learned men of his day, is said to have been made Professor of Logic at the University of Padua when but nineteen years of age. J. B. Ramusio admitted that he owed to Fracastorio the idea and much of the material for his great work "Rac. di Navigazioni e Viaggi," first published in 1550.

Fracastorio made many important astronomical observations, and it was he and Peter Apian who first made known in Europe the fact that comets' tails are always turned away from the sun, so that their line of prolongation passes through its centre.

Gilbert alludes to Fracastorio (*De Magnete*, Book I. chap. i.; Book II. chaps. ii. iv. xxiv. xxxviii. xxxix.; Book IV. chap. i.), and to his "De Sympathia," of which the first edition is Venet., 1546. This, says Libri, is "an important work in which universal attraction, as well as electric and magnetic motion, is attributed to an *imponderable* principle."

References.—Baillet (Adrien), "Jugement des Savants," Vol. II; Menken (F. O.), "De Vita," Leipzig, 1731; Teissier (H. A.), "Eloges des hommes illustres," tirés de M. De Thou; Libri, "Hist. des. Sc. Mathém.," Paris, 1838, Vol. III. p. 100; "Biog. Gén.," Vol. XVIII. pp. 418–420; Humboldt, "Cosmos," 1849, Vol. I. p. 86; Vol. II. p. 697; Larousse, "Dict. Univ.," Vol. VIII. pp. 692–693; Houzeau et Lancaster, "Bibl. Gén.," Vol. II. p. 135.

Garcia d'Orta—Garzia ab Horto—Garcia del Huerto—Garcie du Jardin—a Portuguese physician and the author of "Coloquios

dos simples . . . pello douctor Garcia Dorta," 1563, which was translated into French and united to the works of C. d'Acosta and Nic. Monardes (Christophile de la Coste et M. Nicholas Monard) in 1567, 1574 and 1579. The passage which Gilbert alludes to (in *De Magnete*, Book I. chap. xiv.), is to be found in the abridged Latin translation of Garcia's work made by Charles de l'Ecluse, Antwerp, 1593, lib. i. cap. 56, pp. 178–179. Hakewill observes (" Apologie," 1635, lib. ii. p. 165): " Remarkable indeed, that is which Garzias ab Horto writes concerning the loadstone in *Simpl. Indicæ*, lib. i. cap. 47."

References.—" Biog. Gén.," Vol. XXXVIII. p. 887; Machado (Barb.), " Bibliotheca Lusitana "; Denis (Ferdinand), " Bulletin du Bibliographe "; Pincio (Léon), " Biblioteca Oriental y Occidental "; " Histoire des Drogues par Antoine Collin," Lyon, 1619; " Thesaur. Lit. Bot.," 1851, p. 127.

Gauricus, Lucas (1476–1558), Italian mathematician and astronomer, one of whose pupils was César Scaliger, is the author of twenty-one different works (" Opera Omnia," Basle, 1575), of which the best known are " Rerum naturalium et divinarum . . ." 1540; " Isagogicus . . . in totam astrologiam prædictivam . . ." 1546; " Tractatus Astrologicus," 1552; " Tabulæ de primo mobili," 1560.

Gilbert says (*De Magnete*, Book I. chap. i.) the astrologer Lucas Gauricus held that beneath the tail of Ursa Major is a loadstone, and that he assigns the loadstone (as well as the sardonyx and the onyx) not only to the planet Saturn, but also to Mars (with the diamond, jasper, and ruby), so that the loadstone, according to him, is ruled by two planets. Further, Lucas says that the loadstone belongs to the sign Virgo—and with a veil of mathematical erudition he covers many similar disgraceful stupidities.

References.—Ughelli (Ferdinando), " Italia Sacra," Venetiis 1717–1722; Nicodemo (Francesco), " Biblioteca Napoletana "; " Chronicum Mathematicorum," which prefaces the Almagest of Riccioli; " Biog. Gén.," Vol. XIX. pp. 681–683; " La Grande Encycl.," Vol. XVIII. p. 617; Larousse, " Dict. Univ.," Vol. VIII. p. 1087.

Geber—Yeber—Djaber—Abū-Mūsā-Jābir—Ibn Haiyān—Al-Tarsūsi—who, according to Aboulwefa (Michaud, " Dict.," Vol. XVI. p. 100) lived in the eighth century A.D., is the earliest of the Great Arabian chemists or alchemists. Rhazès and Avicenna call him " the master of masters," and, by the author of " The Lives of Alchemystical Philosophers," he is designated as " the prince of those alchemical adepts who have appeared during the Christian Era." As many as five hundred different alchemical works have

been attributed to him, and a complete list of the most important will be found in M. F. Hœfer, " Histoire de la Chimie," Paris, 1842.

REFERENCES.—" Journal des Savants," for May 1851, February 1892, pp. 118–128 *passim*, and for May 1892 (" Geber et ses œuvres alchimiques "), pp. 318–329; Larousse, " Dict. Univ.," Vol. VIII. pp. 1114–1115; Houzeau et Lancaster, " Bibl. Gén.," Vol. II. p. 147; Bolton (H. C.), " Chron. Hist. of Chem.," pp. 985–986; " La Grande Encyclopédie," Vol. XVIII. pp. 680–682; Gilbert, *De Magnete*, Book I. chap. vii.

Gemma, D. Cornelius, a well-known physician of Louvain (1535–1597) and son of the celebrated mathematician Gemma Frisius, is the author of the several works named at p. 854, Vol. XIX of the " Biographie Générale." Of these, the most important is the " Cosmocritice, seu de naturæ divinis . . . proprietatibus rerum " published at Antwerp in 1575.

REFERENCES.—Foppens, " Bibliotheca Belgica "—" Biog. Médicale "; Linden (Joannes Antonides van der), " De scriptis medicis," Amst., 1651, pp. 147–148; Gilbert, *De Magnete*, Book II. chap. iii.

Gemma, Frisius—Rainer—(1508–1555), above alluded to, besides being a mathematician was a medical practitioner. He wrote " De Principiis Astronomiæ et Cosmographiæ . . ." Antwerp, 1530 (now of excessive scarcity and Chapters XXX–XXXI of which deal with America), as well as several other similar works published notably in 1539, 1545, 1548. These are standards of the Netherlands geographical schools, whose most brilliant representative was the well-known geographer, Gerard Mercator (1512–1594).

REFERENCES.—" Biog. Générale," Vol. XIX. p. 854; " La Grande Encycl.," Vol. XVIII. p. 702; Houzeau et Lancaster, " Bibl. Gén.," Vol. L. part i. p. 1405 and Vol. II. p. 148.

Goropius, Henricus Becanus—Jean Bécan—Jean Van Gorp (1518–1572), a Belgian savant who practised medicine at Antwerp and who attempted to prove, in his " Indo-Scythica," that Adam's language was the German or Teutonic. We are told by Gilbert, in the first book of *De Magnete*, that Goropius ascribes the invention of the compass to the Cimbri or Teutons, on the ground that the thirty-two names of the winds thereon inscribed are pronounced in German by all mariners, whether they be British or Spaniards, or Frenchmen.

REFERENCES.—" Opera Joannis Goropii Becani," Antwerp, 1570; Larousse, " Dict. Univ.," Vol. II. p. 457; " Biog. Générale," Vol. V. pp. 70–71; and, for additional citations, as well as for mention of all his works, the " Grande Encyclopédie," Vol. XIX.

Grotius, Hugo, the latinized form of the Dutch *De Groot*—a great theologian and jurist (1583–1645). His singular precocity

attracted Joseph J. Scaliger, who undertook to direct his studies at the Leyden University, where it is said he achieved brilliant success in all studies.

One of his biographers remarks that, in the annals of precocious genius, there is no greater prodigy on record than Hugo Grotius, who was able to write good Latin verses at nine (1592), was ripe for the University at twelve (1595), and at the age of fifteen (1598), edited the Encyclopædic work of Martianus Capella—a writer of the fifth century—with the aid of his father, Jan de Groot, the Delft burgomaster. It might be added that, in 1597, he had delivered public discourses on mathematics, philosophy and jurisprudence; in 1598, he was so highly sought for everywhere, that he was asked to, and did, accompany Count Justin of Nassau and Olden Barneveldt on their special embassy to the French Court, and that, in 1599, he not only took his degree of doctor of law and pleaded his first cases before the Hague Courts, but was able, through his superior knowledge of mathematics, to translate into Latin Simon Stevin's work on navigation. Later on, 1603, he was appointed historiographer of the United Provinces, becoming fiscal general in 1607 (also Council Pensionary at Rotterdam six years later), and during 1609, he published his first work " De Mare Liberum," which was a treatise against the claims of the English to exclusive right over certain seas. This was followed in 1610 by " De Antiq. Reipub. Batavæ," and some years afterwards by his chief work, " De Jure Belli et Pacis," considered the basis of international law and freely translated into all the principal languages. Grotius is twice mentioned in Book IV. chap. ix. of *De Magnete*.

References.—Brandt et Cattenbuch, " Histoire de Hugo de Groot," 1727; Burigny (J. Levêque de), " Vie de Grotius," 1752; Cras (Hendrik Constantijn), " Laudatio Hugonis Grotii," 1796; Dr. Fried. Ueberweg, " Hist. of Phil.," (Morris tr., 1885, Vol. II. p. 31); Rogge (H. C.), " Bibliotheca Grotiana," 1883; Kœnen (Hendrik Jakob), " Hugo Grotius," 1837; " Chambers's Encycl.," Vol. V. pp. 431–432; " La Grande Encycl.," Vol. XIX. pp. 451–452; " Biographisch Woordenbock," J. G. Frederiko en F. J. Van den Branden, Amsterdam, pp. 301–302; Larousse (Pierre), " Dict. Univ.," Vol. VIII. p. 1556, giving list of his many works; Butler (C.), " Life of Grotius," London, 1826; Creuzer (Georg Friedrich), " Luther und Grotius," Heidelberg, 1846; " Biog. Générale," Vol. XXII. pp. 197–216 for a complete record of all his works.

Hali Abas—'Ali Ibn Al-'Abbás—Al Majusí—celebrated Arabian physician, whose death occurred about A.D. 995, is author of " Ketab-el-Maleki," *i. e.* the " Royal Book "—*Liber Regius*—in which he pretends to give all that was then known concerning medicine. Mr. Adams explains (Appendix, " Barker's Lempriére," London, 1838), that he considers the " Royal Book " as the most complete ancient treatise that has reached us on medicine, and the sciences

generally, with exception of the *Synopsis* of Paulus Ægenita. The Latin translation of this work, given in 1127 by Stephanus Antiochenus, was first printed in Venice, 1492, then at Lyons in 1523.

REFERENCES. — Casiri (Michael), "Bibliotheca Arabico-hispana Escur.," Vol. I. pp. 260, 273; Hœfer, "Nouv. Biogr. Univ.," Vol. II. pp. 96–97; Michaud, "Biog. Univ.," Paris, 1843, Vol. I. p. 468; Gilbert, *De Magnete*, Book I. chap. i.; Freind (John), "History of Physick"; Choulant (Johann Ludwig), "Handbuch der Bücherkunde . . ."; Wüstenfeld (H. F.), "Geschichte d' Arab. Ærzte," p. 59; "Biog. Gén.," Vol. II. pp. 96–97.

Harriot, Thomas (1560–1621), one of the learned Englishmen alluded to by Gilbert, at the end of the first chapter, Book I of *De Magnete*, as having on long sea voyages observed the differences of magnetic variation, was a mathematician and astronomer, whose miscellaneous works, noted at pp. 437–439, Vol. XXIV of the "Dict. of Nat. Biog.," embrace treatises on magnetism, mechanics, etc. The account he has given of his voyage to Virginia was printed in Hakluyt's "Principal Navigations," Vol. III and is pronounced "one of the earliest and best examples of a statistical survey made upon a large scale," at p. 11, Vol. LXXI of the "Edinburgh Review."

Heraclides of Pontus and Ecphantus, was a Greek historian and philosopher who died about 330 B.C. Diogenes Laertius attributes to him many works that have not reached us, and we have nothing of him but fragments of his treatise on the constitutions of the different States which have been printed with the works of Elien. Gilbert commences the third chapter of his sixth book by saying that Heraclides, as well as the Pythagoreans Nicetas of Syracuse and Aristarchus of Samos, and, as it seems, many others, held that the earth moves, that the stars set through the interposition of the earth, and that they rise through the earth's giving way: they do give the earth motion, and the earth being, like a wheel, supported on its axis, rotates upon it from west to east.

REFERENCES.—Rowles (S.), "De Vita et Scriptis," 1824, Vol. VIII; Deswert (Eugenius), "Dissert. de Heraclide Pontico," 1830; Krische (August Bernhard), "Forschungen . . ." p. 325; "La Grande Encyclopédie," Vol. XIX. p. 1131; Dr. F. Ueberweg, "History of Philosophy," tr. by Geo. S. Morris, New York, 1885, Vol. I. pp. 38–42; Humboldt, "Cosmos," 1860, Vol. II. p. 309; "Essai théorique . . . des connaissances humaines," par G. Tiberghien, Bruxelles, 1844, Vol. I. pp. 182–185; Larousse, "Dict. Univ.," Vol. IX. p. 200.

Hermes Trismegistus (or "thrice great") is the supposed author of many Greek works that have reached us and which constitute an encyclopædia of Egyptian wisdom in that they treat of astronomy, medicine, and other sciences. As one of his biographers has it,

the principal tenets of the Hermetic Books are that the Creator made the Cosmos by his word out of fluid . . . that death and life are only changes and that nothing is destructible . . . that passion or suffering is the result of motion. . . . Gilbert only refers to him in Book V. chap. xii. by saying that Hermes, Zoroaster and Orpheus recognize a universal soul. Clemens Alexandrinus, who has given an account and catalogue of his writings, makes him the author of six books of physic and of thirty-six books of divinity and philosophy.

References.—"The Works of George Berkeley," by A. C. Fraser, Oxford, 1901, Vol. III. pp. 209, 253–255, 261, 267, 280; Baumgarten—Crusius (Ludwig Friedrich Otto), " . . . de librorum Hermeticorum . . ." 1827; "Dict. of Philos. and Psychol.," by J. M. Baldwin, New York, 1901, Vol. I. p. 475; "Hermes Trismegistus," by Scheible (J.), 1855; Alex. Chalmers, "Gen. Biog. Dict.," London, 1814, Vol. XVII. p. 396; "Hermes Trismegistus," by Parthey (Gustav Friedrich Constantin), 1854; Houzeau et Lancaster, "Bibl. Gén.," Vol. I. part i. pp. 427–428, 691–694; Larousse, "Dict. Univ.," Vol. IX. p. 228; and the long list of citations in "Biog. Générale," Vol. XXIV. pp. 377–382.

Hero—Heron—of Alexandria, a Greek mathematician, pupil of the celebrated Ctesibius who flourished in the third century before Christ and to whom have been attributed many ancient writings upon different technical subjects. Allusion is made by Gilbert (*De Magnete*, Book II. chap. ii.), to Hero's "Spiritualia," which is his most valuable known work and which has been often translated, notably into Latin, 1575, 1680, 1683, into Italian, 1547, 1589, 1592, 1605; and into German, 1687, 1688.

References.—Hultsch (Friedrich), "Heronis Alex.," 1864–1874; Montucla (J. F.), "Hist. des Mathém.," Vol. I. p. 267; "Abhandlungen zur Geschichte der Mathematik," Vol. VIII. pp. 175–214; Martin, "Sur la vie et les ouvrages d'Héron d'Alexandrie"—Mém. de l'Acad. des Ins. B. L., Paris, 1854, ss. 438–439; Arago (François), "Eloge de Watt" (*Œuvres*, Vol. I); Fabricius (Johann Albert), "Bibliotheca Græca," Vol. IV. p. 234; Figuier (Louis), "Hist. des principales découvertes," Vol. I. p. 42; "A short history of Greek Mathematics," Jas. Gow, Cambridge, 1884, pp. 276–286; Larousse, "Dict. Univ.," Vol. IX. p. 241; "Chambers's Encyclopædia," Vol. V. p. 689; ninth "Encycl. Britan.," Vol. XI. p. 760; "La Grande Encyclopédie," Vol. XIX. p. 1200; "Journal des Savants" for March 1903, p. 147, and for April 1903, p. 203; "Biogr. Générale," Vol. XXIV. pp. 447–449; Th. Martin ("Mém. Ac. des Inscr.," 1854); also two papers by Boncompagni and Vincent in "Bulletino di Bibliog.," Vol. IV.

Hipparchus the Rhodian, "le plus grand astronome de l'antiquité"—born, according to Strabo, at Nicæa in Bithynia, 160–145 B.C.—is the inventor of the astrolabe [1] and discoverer of "the precession of the equinoxes." He is mentioned by Gilbert five times in Book VI. chaps. ii. viii. ix. of *De Magnete*, and is ex-

[1] See résumé concerning the Astrolabe at A.D. 1235–1315—Raymond Lully.

tensively treated of in the "Journal des Savants" for November 1828, January 1829, August and September 1831, October 1843, August and September 1848, July 1859; also by the Rev. H. M. Close, in "Proc. of Roy. Irish Acad.," Series III. vol. vi. No. 3, in Larousse, "Dict. Univ.," Vol. IX. p. 286, in the "Historical Account of Astronomy," by John Narrien, London, 1833, pp. 219–244, and in the "Astronomy" article of the "Encyclopædia Britannica."

By Humboldt, Hipparchus is called the founder of scientific astronomy and the greatest astronomical observer of antiquity. He was the actual originator of astronomical tables amongst the Greeks and, in the new map of the world which he constructed and founded upon that of Eratosthenes, the geographical degrees of latitude and longitude were based on lunar observations, and on the measurement of shadows, wherever such an application of astronomy was admissible ("Cosmos," London, 1849, Vol. II. p. 545; Ideler, "Handbuch der Chronologie," Vol. I. ss. 212, 329).

The mathematician Eratosthenes, alluded to above, was a native of Cyrene, and pronounced the most celebrated of the Alexandrian librarians. He is reported to have made the earliest attempt at measurement of an arc of the meridian. The next measurement of record is that of the astronomers of Almamon in the plains of Mesopotamia ("Encycl. Brit.," ninth edition, Edinburgh, 1876, Vol. X. p. 177). The first arc of the meridian measured in modern times with an accuracy any way corresponding to the difficulty of the problem was by Snellius, who has given an account of it in his most remarkable work called "Eratosthenes Batavus," published at Leyden in 1617 ("Ency. Brit.," ninth edition, Vol. VII. pp. 597, 606, also eighth edition, Vol. I. pp. 617–618; "Cosmos," London, 1849, Vol. II. p. 544, and Chasles, "Recherches sur l'astronomie . . ." in the *Comptes Rendus*, Vol. XXIII, 1846, p. 851). The biographers of Snellius—Snell van Roijen (Willebrood)—state that he was a very celebrated Dutch astronomer (1591–1626), the discoverer of the law of refraction generally attributed to Descartes (Humboldt, "Cosmos," 1849, Vol. II. p. 699), the author of a treatise on navigation ("Tiphys Batavus," Leyde, 1624) after the plan of Edward Wright, and that the method he employed (with imperfect instruments), for measuring an arc of the meridian has since been followed by all scientists ("La Grande Encyclopédie," Vol. XXX. p. 115; "Nouv. Biog. Gén.," de Hœfer, Vol. XLIV. p. 83; Montucla, "Hist. des Mathém.," Vol. II; Larousse, "Dict. Univ.," Vol. XVI. p. 795; Delambre, "Hist. de l'astronomie moderne," Vol. II. pp. 92–119; "Ency. Brit.," Akron, Ohio, 1905, Vol. XXII. p. 211).

REFERENCES.—Theodor Gomperz, "Greek Thinkers," translation of L. Magnus, London, 1901, p. 544; Houzeau et Lancaster, "Bibl. Gén.," Vol. I. part i. pp. 413–414, and Vol. II. p. 164; "Geographical Journal" for October 1904, p. 411; Wm. Whewell, "Hist. of the Ind. Sc.," New York, 1858, Vol. I. pp. 145–156; "Journal des Savants" for 1828, 1831, 1843; Alex. Chalmers, "Gen. Biog. Dict.," London, 1814, Vol. XVII. pp. 505–506.

Hues—Hood—Robert (1553(?)–1632), another of the English sea voyagers named by Gilbert at the end of his first book, was a mathematician and geographer who sailed around the world with Thomas Cavendish and is the author of "Tractatus de Globis . . . et eorum usu," 1593, 1594, 1627, which was written for the especial purpose of being used in connection with a set of globes by Emery Molyneux. This work was shortly afterwards followed by another in the same line entitled "Breviarum totius orbis"—"Breviarum orbis terrarum ("Dict. of Nat. Biog.," Vol. XXVIII. p. 156).

Kendall—Kendel—Abram, who has already been mentioned (Gama, A.D. 1497; Norman, A.D. 1576), is called by Gilbert "the expert English navigator." He was sailing master of the "Bear," a ship belonging to Sir Robert Dudley (1573–1649), on the voyage which is referred to in Vol. IV of Hakluyt's "Collection of the early voyages, travels and discoveries," London, 1811. Therein, at pp. 57 and 58, mention is made of Kendall, who is also favourably alluded to in the very attractive and justly prominent work of Sir Robt. Dudley, published in three volumes at Florence, 1646–1647, 1661, and entitled "Dell Arcano del Mare di Roberto Dudleio, Duca di Nortumbria e Conte di Warwick."

REFERENCES.—"Dict. of Nat. Biogr.," Vol. XVI. p. 125; also Libri's "Catalogues," 1859, Vol. I. p. 160, and 1861, Vol. I. p. 268; Vol. II. p. 573, wherein it is said that amongst the *Portulani* are those of Abraham Kendall and John Diez for the coasts of America and the West Indies.

Kendall is said to have joined, during the year 1595, the last expedition of Francis Drake and to have died the year following. Drake is alluded to in the address by Edward Wright in connection with Thomas Candish (Cavendish), and they are both also mentioned together (*De Magnete*, Book III. chap. i.), where Gilbert calls Drake "our most illustrious Neptune," and Cavendish "that other world-explorer."

REFERENCES.—David Hume, "History of England," London, 1822, Vol. V; "Lives of Drake, Candish and Dampier," Edin., 1831; "Collection of Voyages and Discoveries," Glasgow, 1792; "English Seamen of the Sixteenth Century," by James Anthony Froude, New York, 1896, pp. 75–103, detailing Drake's voyage around the world; "Life of Sir Francis Drake and Account of his Family," reprinted from the "Biog. Britannica," 1828; "The Works of John Locke," London, 1812, Vol. X. pp. 359–512, for the "History of Navigation from its Origin to this Time" (1704), prefixed to "Churchill's Collection of Voyages," and embracing the voyages of Stephen Burrough, Sebastian Cabot, Sir Thos. Candish,

Christopher Columbus, Sir Francis Drake and Vasco da Gama, as well as the discoveries attributed to Gioia and others; making, for the polarity of needle, special mention of Bochart's "Geog. Sacra," p. 716, Purchas' "Pilgrims," p. 26 and Fuller's "Miscellanies," lib. iv. cap. 19; Franciscus Drakus, 1581, is Epig. 39, Liber Secundus, p. 28 of 1747, Amsterodami ed. of "Epigrammatum Ioan Oweni" (John Owen, 1560–1622, "Dict. of Nat. Biog.," Vol. XLII. pp. 420–421). At pp. 437 and 444, Vol. I. of "The History of No' America," by Alfred Brittain, Philadelphia, 1903, will be found a plate portrait of Sir Francis Drake and the reproduction of a page from "Sir Francis Drake Revived," originally published in 1626. The latter is "a true relation of foure severall voyages . . . collected out of the notes of Sir Francis Drake, Philip Nichols and Francis Fletcher. . . ."; "The Voyages of the Cabots," in "Narrative and Critical History of America," by Justin Winsor, Boston, 1889, Vol. III. pp. 1–59–84 for Drake, Hawkins and Cavendish. "Life of Sir Rob. Dudley . . ." by John Temple Leader, Florence, 1895. For Sir Francis Drake and Thos. Candish, consult also Vols. XV and XVI, as per Index, p. 412 of Richard Hakluyt, "The Principal Navigations . . ." Edinburgh, 1889; "General Biog. Dict.," Alex. Chalmers, London, 1813, Vol. XII. p. 305 for Sir Francis Drake and pp. 414–418 for Sir Rob. Dudley.

Lactantius—Lucius Cœlius Firmianus—celebrated orator of Italian descent, called "the Christian Cicero," died about 325–326 A.D. He was a teacher of rhetoric in Nicomedia, Bithynia, was entrusted by Constantine the Great with the education of his son Crispus Cæsar ("History of Christianity," Rev. Hy. Hart Milman, London, 1840, Vol. II. p. 384), and became a very extensive writer. Dufresnoy enumerates as many as eighty-six editions of his entire works, besides separate publications of his different treatises, appearing between the years 1461–1465 and 1739; the best editions being given in Vols. X–XI of the "Bibliotheca Patrum Ecclesiasticorum Latinorum . . ." by Gersdorf (Ephraim Gotthelf), Leipzig, 1842–1844 and in Migne (Jacques Paul) "Patrologiæ," Vols. VI–VII, 1844. His principal work is the "Divinarum Institutionum," the third book of which ("De falsa sapientia") is referred to by Gilbert (*De Magnete*, Chap. III), when he says that Lactantius, like the most unlearned of the vulgar, or like an uncultured bumpkin, treats with ridicule the mention of antipodes and of a round globe of earth.

Geo. Hakewill, who has already appeared in this "Bibliographical History," at A.D. 1627, alludes to the above ("Apologie," Oxford, 1635, lib. iii. p. 281), in manner following: "Yet that which to me seemeth more strange is that those two learned Clearkes, Lactantius (*Divin. Inst.*, lib. iii. cap. 24), and Augustine (*De Civitate Dei*, I. lib. xvi. cap. 9), should with that earnestnesse deny the being of any antipodes. . . . Zachary, Bishop of Rome, and Boniface, Bishop of Mentz, led (as it seems), by the authority of these Fathers, went farther herein, condemning one Vergilius, a Bishop of Saltzburg, as an heretique, only for holding that there were antipodes." Madame Blavatsky ("Isis Unveiled," Vol. I. p. 526)

says : " In 317 A.D. we find Lactantius teaching his pupil Crispus Cæsar, that the earth is a plane surrounded by the sky, which is composed of fire and water, and warning him against the heretical doctrine of the earth's globular form ! "

The following notes concerning the antipodes are likely to prove interesting :

" Pythagoras left no writings—Aristotle speaks only of his school—but Diogenes Laertius in one passage ('Vitæ,' VIII. I. Pythag. 25), quotes an authority to the effect that Pythagoras asserted the earth to be spherical and inhabited all over, so that there were antipodes, to whom that is *over* which to us is *under*. . . . Plato makes Socrates say that he took up the work of Anaxagoras, hoping to learn whether the earth was round or flat ('Phædo,' 46, Stallb. I, 176)." In Plutarch's essay, " On the face appearing in the orb of the moon," one of the characters is lavish in his ridicule of the sphericity of the earth and of the theory of antipodes. (Justin Winsor, " Narrative and Critical History," Boston, 1889, Vol. I. pp. 3–5, notes; Lucretius, " De Rerum," V. pp. 1052, etc., and vi. p. 630; Virgil (Publius V. Maro), " Georgics," I. p. 247; Tacitus (Publius Cornelius), " Germania," p. 45.)

Speaking of the lower hemisphere or antipodes, as well as of islands of magnetic power drawing vessels on their rocks, Albertus Magnus says, in the book " De Natura Locorum," contained in his " Philosophus Philosophorum Princeps " : " Perhaps also some magnetic power in that region draws human stones, even as the magnet draws iron." See the Legends, in Reisch's—Reysch's— " Map of the World," Rome, 1508 (" Christ. Colombus," by J. B. Thatcher, New York, 1903, Vol. I. pp. 165–166).

At the beginning of the fourteenth century, the roundness of the earth and the antipodes were generally recognized. Mention thereof is to be found in the " Trésor " of Brunetto Latini, in the " Divina Commedia," in the " Convito " (Dante, Opere Minori, Vol. I. p. 93), and in the " Acerba " of Francesco degli Stabili (Cecco d'Ascoli), at ff. 8–11, lib. i. cap. 3; as well as in most cosmographical treatises of the fourteenth century (Libri, Vol. II. p. 197, note).

The passage in Lactantius (lib. iii. cap. 24), begins *Ineptum credere*. In the 1570 edition, it commences at Chap. XXIII, " *Aut est* . . ." p. 178. In the " Works of Lactantius," Edinburgh, 1871, Vol. I. chap. xxiv. pp. 196–197, the translator, Wm. Fletcher, says that he thus ridicules the antipodes and the roundness of the earth : " . . . the rotundity of the earth leads, in addition, to the invention of those suspended antipodes," whilst, at Vol. II. chap. xxxix. p. 122, Lactantius says again that " about the antipodes, also, one can neither hear nor speak without laughter."

Sopra li cieli nel beato regno
Doue lumanno ſpirito e beniegno
Concluſione de tuta lopera
Ello e il tacer de cotanta coſa
b Cõſiderãdo il mio poco itelectõ
Ma la grã fede m̃ moue & eſcoſa
Si che prego la uirtu di ſopra
Che alumi lalma del beato aſpecto
Et che limaginar ſeguiſca lopra
Et tal figluol nantil moto el tempo
El padre col figluol una natura
Eterna che non cade mai ſul tempo
Che fia eta ĩprima preſol primo agẽte
Et eſſer tuto per lui rien figura
Et facto ſenza lui dico e niente
Et zo che facto era uita in lui
Et cio per fede confeſſiamo nui
Si come forma ne la mente eterna
E in queſta ui: luce mai ſinterna.

Finiſe il libro de Ciecho Eſculano dictõ Lacerba. Impreſſo ne lalma patria de ueneſia p maiſtro philipo de piero ne gli ãni del. M CCCC. LXXVI.

Cecco D'Ascoli. Last page of the earliest known edition of his "Acerba" Venetia 1476.
Printed nineteen times up to and including the edition of 1546.
Now in the Bibliothèque Sainte Geneviève, Paris.

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sa pendere : fruges & arbores deorsum uersus crescere : pluuias & niues et
grandines sursum uersus cadere in terram. Et miratur aliquis ortos pen-
siles inter septem mira narrari. cū philosophi & agros et maria & urbes et
mōtes pensiles faciant. Huius quoq; erroris aperiēda nobis origo est. Nā
semp̄ eodem modo falluntur. Cum eni falsum aliquid in pncipio sumpserint :
uerisimilitudine inducti : necesse est eos in ea quę consequuntur currere. sic
incidunt in multa ridicula. quia necesse est falsa esse : quę rebus falsis con-
gruūt. Cum autē primis habuerint fidem : qualia sunt ea que sequūtur non
circūspiciunt. sed defendunt oī modo. cum debeant pma illa utrū ne uera
sint an falsa ex consequentibus iudicare. Quę igit̄ illos ad antipodas ratio
perduxit? Videbat siderū cursus in occasum meantiū. solem atq; lunam in
eandem partem semp̄ occidere : atq; oriri semper ab eadem. Cum autē non
perspicerent quę machinatio cursus eorū tēparet : nec quomō ab occasu ad
orientem remeant. Cęlum antē ipm in oēs fere partes putarēt eē deuexū.
quod sic uideri ꝓpter imensam latitudinem necesse est. Existimauert rotū-
dum esse mūdum sicut pilam. Et ex motu siderū opinati sunt coelum uolui.
sic astra solemq; cū occiderint uolubilitate ipa mundi ad ortū referri. Itaq;
ęthereos orbes fabricati sunt. quasi ad figuram mūdi : eosq; cęlarūt porten-
tosis quibusdam simulacris quę astra esse dicerent. Hanc igit̄ coeli rotūdi-
tatem illud sequebatur : ut terra in medio sinu eius esset inclusa. ꝙ si ita esset
terram ipam globo similem. neq; ei fieri posset. ut non esset rotūdum : quod
rotūdo inclusum teneretur. Si autē rotunda etiam terra esset : necesse est ut
in oēs coeli partes eādem faciem gerat. id est. mōtes erigat : cāpos tēdat :
maria consternat. Quod si esset : sequebat̄ illud extremū : ut nulla sit pars
terrę quę non ab hōibus : cęterisq; aīalibus incolat̄. Sic pendulos istos an-
tipodas cęli rotunditas adinuenit. Quod si queras ab his qui hęc portenta
defendunt : quomō non cadunt oīa in inferiorē illam cęli partem? Hanc
respondent rerū esse naturā : ut pondera in mediū ferantur. et ad medium
conexa sint oīa : sicut radios uidemus in rota. Quę autē leuia sunt ut ne-
bula : fumus : ignis : a medio deferant̄ ut cęlum petant. Quid dicam de his
nescio : qui cū semel aberrauerint : constāter in stultitia perseuerāt. et uanis
uana defendūt. nisi ꝙ eos interdum puto ioci causa philosophari. aut pru-
dentes & scios mendatia defendenda suscipere. q̄si ut ingenia sua in malis
rebus exerceāt uel ostendant. At ego multis argumentis probare possem :
nullo mō fieri posse : ut cęlū terra sit inferius : nisi et liber iam concludendus
esset. ut adhuc aliqua restarent quę magis sint presenti operi necessaria. Et

Lactantius. "De Divinis Institutionibus." Page taken from the 1465 edition.
In the Bibliothèque Ste. Geneviève, Paris.

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In "Christian Schools and Scholars," Augusta Th. Drane, London, 1867, p. 70, Albertus describes the antipodes and the countries they embrace.

Robert Steele, in his "Mediæval Lore," London, 1893, p. 75, has it: "And fables tell, that there, beyond the antipodes be men that have their feet against our feet."

At p. 200 of André Pezzani's "La Pluralité des Existences de l'Ame," Paris, 1866, he mentions that Cardinal Nicolas De Cusa admits the roundness of the earth, the plurality of worlds, etc.

For antipodes and roundness of the earth see, likewise: Libri, "Hist. des Sc. Mathém.," Vol. II. pp. 178, 182, note; Ch. W. Shields, "The Final Philosophy," New York, 1877, p. 46; "Le Journal des Sçavans," Vol. XXXVI for 1707, p. 510, wherein it is said that Plutarch denied the antipodes, as did both Lactantius and Saint Augustine. Consult, also, the volumes of "Le Journal des Sçavans" for the years 1710 and 1721.

References.—Dupin (André M. J. J.), "Biblioth. des Auteurs Eccles.," Vol. I. p. 295; Celier (Léonce), "Hist. des Auteurs Sacrés," Vol. III. p. 387; Schöll (Carl), "Hist. de la Lit. Romaine," Vol. IV. p. 26; "Biog. Gén.," Vol. XXVIII. pp. 611–620; ninth "Encycl. Brit.," Vol. XIV. pp. 195–196; Lenain de Tillemont, "Hist. Eccles.," Vol. VI; Fleury (Claude), "Historia Ecclesiastica" ("The Eccles. History from A.D. 400 to A.D. 456"), Vol. I; "History of the Decline and Fall of the Roman Empire," by Edward Gibbon (Milman), Philad. 1880, Vol. II. p. 248 note; "Anti-Nicene Christian Library," edited by Drs. Roberts and Donaldson.

Lusitanus, Amatus—Joan Rodrigo Amato—Portuguese physician (1511–1568), is author of several medical essays wherein he advocates the views of Galen and of the Arabian School. His most important work is "Curationum medicinalium centuriæ septem," and is so named because it is divided into seven parts, each containing a hundred different observations and reports on medical cures, etc. In *De Magnete*, Book I. chap. i., Gilbert names him amongst authors, like Antonius Musae Brasavolus and Joannes Baptista Montanus, who tell of the efficacy of the loadstone in medicine.

References.—"Thesaurus Literaturæ Botanicæ," Lipsiæ, 1851, pp. 334–335; Larousse, "Dict. Univ.," Vol. X. p. 796; "Dict. Hist. de la Médecine," par N. F. J. Eloy, Mons, 1778, Vol. I. pp. 106–107.

Lynschoten—Linschooten—Jan Huygan van—who, with Richard Haklüyt, we find mentioned by Edward Wright in his Address "to the most learned Mr. William Gilbert," was a celebrated Dutch navigator (1563–1611) who accompanied Vicente Fonseca, Archbishop of Goa, upon his Eastern trip and first published a relation thereof during the year 1601. He is the author, also, of "Itinerario

Voyage ofte Schipvært," Amstelredam, 1596, 1604, 1605, 1623, and " Itinerarium, ofte Schipvært," Amsterdam, 1614.

REFERENCES.—Lautz (G.), " Biog. de J. H. Van L.," Amst., 1845; Du Boys (Pierre), " Vies des Gouverneurs," p. 4; " La Grande Encycl.," Vol. XXII. p. 299; Larousse, " Dict. Univ.," Vol. X. p. 542; " Biog. Générale," Vol. XXXI. p. 303.

Machometes Aractensis. *See* Albategnius.

Marbodeus Gallus, surnamed Pelliciarius, who is briefly mentioned twice by Gilbert in *De Magnete,* Book I. chap. i., was a French writer, son of a merchant (Marbode, Marbœuf) who finally became Bishop of Rennes in 1081, and died at Angers in 1123–1125. He is best known by his poetical works, which were first published in 1524. As has already been said, Marbodeus is suppósed to have used the manuscript of Evax-Euace—to make up his own book on precious stones. The latter work is alluded to by J. B. Hauréau in the second of his articles on the Latin MSS. of the Palatine—" Codices Palatini Bibliothecæ Vaticanæ "—wherein the first line is quoted:

"*Evax, rex Arabum, fertur scripisse Neroni*"

(" Journal des Savants," Sept. 1887, p. 565, June 1891, p. 372; " Hildeb. et Marbod. Opera," Col. 1637).

Bertelli quotes, at p. 96 of his " Pietro Peregrino " Memoir, four of the Latin lines, as well as those of Hildeberti, which can be translated as follows:

" The magnet stone is found amongst the Troglodites,
The same stone which India, its mother, sends;
This one is known to be of ferruginous colour
And its nature is to draw iron when near it."

REFERENCES.—" The Lapidarium of Marbodus " (with translation of the sixty-one chapters) at pp. 389–417 of " Antique Gems," by Rev. C. W. King, London, 1866; " Gallia Christiana," XIV. col. 746; " Hist. Lit. de la France," Vol. X. p. 343; " La Grande Encycl.," Vol. XXIII. p. 15; Larousse, " Dict. Univ.," Vol. X^2. p. 1126; " Biographie Générale," Vol. XXXIII. pp. 366–367.

Marco Polo. *See* A.D. 1271–1295, p. 55.

Matthæus Silvaticus. *See* Silvaticus.

Matthiolus, Petrus Andreas—Pierre André Mattiole—(1500–1577), Italian naturalist and physician, is best known by his Commentary originally published at Venice under the title " Il Dioscoride con gli suoi discorsi " and translated into Latin, 1554, which is said to contain all that was known of medicine and botany up to that time (Larousse, " Dict. Univ.," Vol. X. p. 1349; Eloy, " Dict. Hist. de Médecine," Mons, 1778, Vol. III. pp. 190–193.

Gilbert tells, in Book I. chap. i. of *De Magnete,* that Matthiolus,

the translator of Dioscorides," furbishes again the garlic and diamond story, in connection with the loadstone, that he also brings in the fable of Mahomet's shrine having an arched roof of magnets so that the people might be fooled by the trick of the coffin suspended in air, as though 'twere some divine miracle, and, furthermore, that he compares the attractive virtues of the loadstone, which pass through iron, to the mischief of the *torpedo,* whose poison passes through bodies and spreads in an occult way."

Maurolycus—Marulle—Franciscus (1494–1575) was Abbot of Messina and a celebrated geometer. His well-known "Opuscula Mathematica," Venice, 1575, containing treatises on the sphere, astronomical instruments, etc., was preceded by his great book on Cosmography published during 1543, and he also wrote many other works which will be found enumerated in the Catalogue so ably made up by the Abbé Scina (Larousse, "Dict. Univ.," Vol. X. p. 1365; Houzeau et Lancaster, "Bibl. Gén.," Vol. II. p. 201).

Gilbert mentions Franciscus Maurolycus (*De Magnete,* Book I. chaps. i. and xvii., also Book IV. chaps. i. and xviii.), regarding the variation in the Mediterranean Sea and says that he discusses a few problems regarding the loadstone, adopting the current opinion of others, and that he believes the variation is caused by a certain magnetic island mentioned by Olaus Magnus.

References.—Libri, "Hist. des Sc. Mathém.," Paris, 1838, Vol III. p. 102; "Nouv. Biog. Gén." (Hœfer), Vol. XXXIV. p. 428; "Vita del Abate. Maurolico," Messine, 1613; Nicéron, "Mémoires," Vol. XXXVII; "Biog. Univ." (Michaud), Vol. XXVII. p. 352; Tessier (H. A.), "Eloges des hommes Illustres"; "Dict. Univ. du XIXe siècle" (Larousse), Vol. X. p. 1365.

Menelaus (called also Mileus, Milleus, by Apian and by Mersenne), was a celebrated Alexandrian, living end of first century A.D., who, in his brilliant treatment especially of spherical geometry, went considerably beyond all his predecessors. The only work of his, however, that has reached us is a treatise on the sphere in three books, of which the translation was made by Maurolycus and inserted by P. Mersenne in his "Univ. Geometriæ Synopsis," 1644.

Menelaus is mentioned by Gilbert (*De Magnete,* Book VI. chaps. viii. and ix.) together with Ptolemy and Machometes Aractensis, who, says he, have held in their writings that the fixed stars and the whole firmament have a forward movement, for they contemplated the heavens and not the earth and knew nothing of magnetic inclination.

References.—Montucla, J. F., "Hist. des Mathém.," Vol. I. p. 291; Delambre, J. B. J., "Hist. de l'Astron. Moderne," Vol. II. p. 243.

Merula, Gaudentius, was an Italian savant living early in the

sixteenth century, author of "De Gallorum . . . antiquitate," 1536, 1538, 1592, of "Memorabilium" 1546, 1550, 1551, 1556, and of several general histories, etc. Gilbert says (*De Magnete*, Book I. chap. i.) Merula advises that on a loadstone be graven the image of a bear, when the moon looks to the north, so that, being suspended by an iron thread, it may win the virtue of the celestial Bear.

References.—Cotta (Lazaro Agostino), "Musæo Novarese," p. 133; Philippo Argellati, "Bibliotheca . . . Mediol. . . ." Vol. II. pp. 2131–2134; "La Grande Encycl." Vol. XXIII. p. 732; "Biog. Gén.," Vol. XXXV. p. 127.

Montagnana, Bartholommeo, who is briefly alluded to at the end of Book I. chap. xv. of *De Magnete*, was the head of a well-known family of Italian physicians. He was born about 1400, practised medicine at Bologna and Padua, and wrote "Consilia Medica, edita Paduæ anno 1436," also "De Balneis Patav.; de compositione et dosi medicamentorum," the latter appearing at Padua in 1556.

References.—Papadopoli (Nicolaus Comnenus), "Historia Gymnasii Patavavini," I; Manget (Jean Jacques), "Bibliotheca Scriptorum Medicorum"; "Bog. Générale," Vol. XXXVI. p. 34.

Montanus, Arias—Benedictus (1527–1598), eminent Spanish Catholic divine and orientalist, member of the Council of Trent, is best known by his Polyglott Bible—*Biblia Regia* or *Biblia Plantiniana*—though he is the author of many works, mostly religious, published during the years 1569, 1571, 1572, 1574 and 1593. Upon completing the last of the eight folio volumes of the *Biblia*, he was offered, but declined, a bishopric by King Philip II, at whose request he had undertaken the work and who, later on, rewarded him with a liberal pension and other emoluments.

He is but briefly referred to by Gilbert, *De Magnete*, Book I. chap. i.

References.—Antonio (Nicolas), "Bibl. Hisp. Nova"; D. Nicol. M. Serrano, "Appendice al Dicc. Univ.," Madrid, 1881, Vol. XIV. p. 407; "Diccionario Enciclopedico Hispano-Americano," Barcelona, 1887, Vol. II. p. 596; Loumyer (C.), "Vie de B. A. Montano," 1842; "Biog. Gén.," Vol. III. pp. 145–146; Rosenmüeller (Ernst Friedrich Carl), "Handbuch für die Literatur," Vol. III. p. 296; Colomiès (Paul), "Italia et Hispania Orientalis," p. 241.

Montanus—Da Monte—Joannes Baptista (1488–1551), already mentioned in connection with Lusitanus, was a Professor of Medicine at the Padua University and regarded as one of the most celebrated physicians of his day. He is the author of many valuable works, including "Metaphrasis Summaria," 1551, "De Differentiis Medi-

camentorum," 1551; "In Nonum librum; Rhazès ad Almansorem Expositio," 1554, 1562.

References.—Tiraboschi (Girolamo), "Storia della Letteratura Italiana"; Facciolati (Jacopo), "Fasti Gymnasii Patavini," par. III; Gilbert, *De Magnete*, Book I. chap. i.; "Biog. Générale," Vol. XXXVI. pp. 108–109.

Myrepsus—Myrepsius—Nicolaus, Greek physician, living in the thirteenth century, became very prominent in Rome as a great student of the Arabic writers. He is the author, more particularly, of a medical treatise, divided into forty-eight sections containing as many as two thousand six hundred and fifty-six formulæ, which was translated by Leonard Fuchs under the title "Nic. Myr. Alex. medicamentorum opus," Basle, 1549, and frequently reprinted, whilst another translation was made by Nicolas de Reggio, who, like Matthæus Silvaticus, was a physician at Salerno and who called it "Nic. Alex. liber de compositione medicamentorum," Ingoldstadt, 1541. The last-named work has, by some, been confounded with the "Antidotarium" of Nicolas Præpositas.

Myrepsus is spoken of by Gilbert, Book I, at end of chap. xiv. *De Magnete* treating of the medicinal virtue of the loadstone. Nicolaus, says he, puts into his "divine plaster" a good deal of loadstone, as do the Augsburg doctors in their "black plaster" for fresh wounds and stabs; because of the exsiccating effect of the loadstone without corrosion, it becomes an efficacious and useful remedy. Paracelsus, in like manner, and for the same end, makes loadstone an ingredient of his plaster for stab wounds.

References.—Fabricius (Johann Albert), "Bibliotheca Græca," Vol. X. p. 292; Vol. XII. pp. 4, 346; Kastner (Christian Wilhelm), "Medicin. Gelehrten-Lexikon," p. 577; Freind (John), "Hist. of Physic," Vol. I. p. 464; Hœfer (M. F.), "Hist. de la Chimie," Vol. I; Sprengel (Kurt Polycarp Joachim), "Geschichte der Arzneikunde," Vol. II. p. 334; Larousse, "Dict. Univ.," Vol. XI. p. 744; "Biog. Générale," Vol. XXXVII. p. 92.

Nicander of Colophon, whom Gilbert mentions twice in his first book, chapter ii., "On the loadstone, what it is: its discovery"—was a Greek poet and physician who lived second century B.C. and of whom comparatively little is known. Only two of his many reported works remain: these are treated of at pp. 917–920, Vol. XXXVII of the "Biographie Générale," where can likewise be found the titles of all the others according to Fabricius (Johann Albert), "Bibliotheca Græca," Harles edition, Vol. IV. p. 345).

References.—Haller (Albrecht von), "Bibliotheca Botanica"; Charlant (Johann Ludwig), "Handb. . . . die Ælter Medicin"; G. A. Pritzel, "Thesaur. Lit. Bot.," 1851, pp. 210–211.

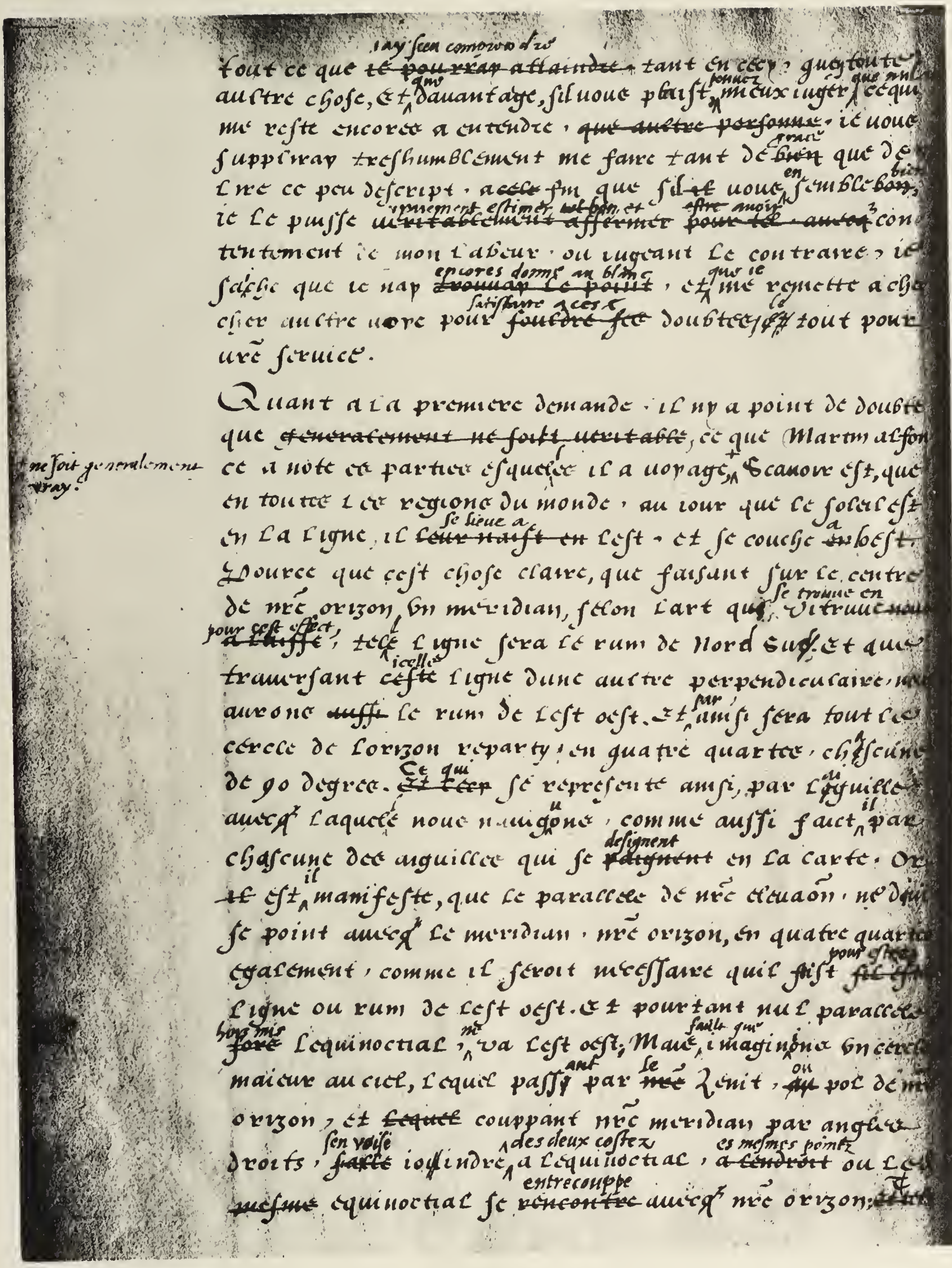
Nicetas—Hicetas—of Syracuse, a Pythagorician of the fourth century B.C., native of Chonæ in Phrygia (the old Colossæ of St. Paul) alluded to by Gilbert in conjunction with Heraclides of Pontus, was doubtless the first, according to Diog. Laert (VIII, 85), to teach the earth's rotation. Humboldt remarks (" Cosmos," 1860, Vol. II. p. 109) that Nicetas, Theophrastus and Heraclides Ponticus appear to have had a knowledge of the rotation of the earth upon its axis; but Aristarchus of Samos, and more particularly Seleucus of Babylon, who lived one hundred and fifty years after Alexander, first arrived at the knowledge that the earth not only rotated on its axis, but also moved around the Sun as the centre of the whole planetary system. Cicero, " Academica," lib. iv. cap. 39: " Nicetas of Syracuse," as Theophrastus says, " believed that the heavens, the sun, the moon, the stars—in brief, all things above—stand still; alone, the earth, of all things in the world, moves. Because it is rapidly turning and twisting upon its axis, it gives the effect of the whole sky moving, and that the earth stands."

REFERENCES.—Fabricius (Johann Albert), " Biblioth. Græca," Vol. I. p. 847; " Biog. Générale," Vol. XXIV. p. 642; " La Grande Encycl.," Vol. XX. p. 63; Houzeau et Lancaster, " Bibl. Gén.," Vol. II. p. 214; Gilbert, *De Magnete*, Book VI. chap. iii.

Nuñez, PEDRO—Nonius, Petrus—was a celebrated Portuguese mathematician (1492–1577) who, after his voyage to the East Indies, became chief cosmographer of the kingdom, and made a great many improvements in astronomical instruments, the merits of which were recognized notably by Tycho Brahé and by Dr. Halley. Of all his books, the most important are the " Tratado da sphera . . . " 1537; " De arte atque ratione navigandi," 1546; " Opera Mathematica," 1566 (containing many treatises on navigation, instruments, sailing cards, etc.); " Annotaçoes à Sphera de Sacro Bosco," 1567 [1]; " Instrumenta Artis Navigandi," 1592. Stockler observes

[1] Sacro Bosco, here alluded to, is John Holywood or Halifax—in Latin, Johannes de Sacro Bosco or Sacro Busto—an English mathematician, said to have studied at Oxford and to have afterwards become a Professor of Astronomy at the University of Paris about the year 1230. Sacro Bosco was one of the first, in the Middle Ages, to avail himself of the Arabian writings on astronomy and is believed to have condensed pretty much all the science therein contained in his own well-known " Tractatus de Sphæra." Of the latter, which was the second astronomical work to appear in print and which was first issued at Ferrara in 1472, there were, it is said, as many as twenty-four more editions published before the year 1500. Houzeau says this " Tractatus " was the standard for three centuries, and the writer in " La Grande Encyclopédie," Vol. XXIX. p. 44, states that there were more than seventy Latin editions of it published between the fifteenth and the seventeenth centuries.

He is also the author of numerous other works, including " De Astrolabio " and a very meritorious " Tractatus de Arte Numerandi," which latter is


i'ay sceu comprendre

tout ce que ~~ie pourray attaindre~~ tant en cecy, que toute
aultre chose, et que dauantage, sil vous plaist donner mieux iuger, ce que nul
me reste encores a entendre, ~~que aultre personne~~ ie vous
suppliray treshumblement me faire tant de ~~bien~~ grace que de
lire ce peu descript, ~~affin~~ fin que sil en vous semble bon,
ie le puisse ~~veritablement affermer~~ vrayement estimer ~~et bon~~ et ~~pour ... auoir~~ estre asseure contentement de mon labeur, ou iugeant le contraire, ie
sache que ie nay encores donne au blanc ~~trouuay le point~~, et que ie me remette a chercher aultre voye pour satisfaire a cest ~~souldre~~ ~~ses~~ doubte le tout pour
vre seruice.

Quant a la premiere demande, il ny a point de doubte
que ~~generallement ne soit veritable~~, ce que Martin alfonse a note es parties esquelles il a voyage, ne soit generalement vray. Scauoir est, que
en toutes les regions du monde, au iour que le soleil est
en la ligne, il ~~leur naist en~~ se lieue a lest, et se couche ~~en~~ a loest.
Pource que cest chose claire, que faisant sur le centre
de nre orizon, vn meridian, selon lart que se trouue en Vitruue ~~nous~~ ~~a laisse~~ pour cest effect, telle ligne sera le rum de Nord Sud. Et que
trauersant ~~ceste~~ icelle ligne dune aultre perpendiculaire, nous
aurons ~~aussi~~ le rum de lest oest. Et par ainsi sera tout le
cercle de lorizon reparty en quatre quartes, chascune
de 90 degres. ~~Et lors~~ Ce qui se represente ainsi, par leguille
auecq laquelle nous nauiguons, comme aussi faict il par
chascune des aguilles qui se ~~paignent~~ designent en la carte. Or
~~il~~ il est manifeste, que le parallele de nre eleuation, ne diuise point auecq le meridian, nre orizon, en quatre quartes
egalement, comme il seroit necessaire quil fist pour estre
ligne ou rum de lest oest. Et pourtant nul parallele
~~fors~~ hors mis lequinoctial, nest va lest oest. Mais il fault que imaginons vn cercle
maieur au ciel, lequel passant par le ~~nre~~ zenit, ou pol de nre
orizon, et ~~lequel~~ coupant nre meridian par angles
droits, sen voise ~~faille~~ ioindre des deux costez a lequinoctial, es mesmes points ~~a lendroit~~ ou le
~~mesme~~ equinoctial se entrecouppe ~~rencontre~~ auecq nre orizon. Et

Pedro Nuñez, " Traitte . . . de la Navigation."
Page 9 *verso* of Ms. Fr. No. 1338, now in the Bibliothèque Nationale, Paris.

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that the last-named treatise, which is an amplification of the 1537 "Tratatos das cartas de marear," would alone justify placing Nonius among the most distinguished geometricians of his time.

REFERENCES.—Fernandez de Navarette, "Recherches . . . sciences nautiques" (tr. M. D. de Mofras), Paris, 1839; Varnhagen (Francisco Adolfo de), "Historia geral do Brazil"; Machado (Barb.), "Biblioth. Lusitana"; Houzeau et Lancaster, "Bibl. Générale," 1887, Vol. I. part i. pp. 216, 574–575, and part ii. p. 1222; Gilbert, *De Magnete*, Book IV. chap. viii.; "La Grande Encycl.," Vol. XXV. p. 140; "Biographie Générale," Vol. XXXVIII. pp. 361–363; "Estromento de Sombras" of Pedro Nuñez, copied in Dr. G. Hellmann's "Neudrucke," 1898, No. 10; J. F. Montucla, "Hist. des Mathém. . . ." (Supplément), Vol. II. pp. 656–659, for names of many other authors of treatises on navigation. For Sacro Bosco: "Dict. of National Biography," edited by Sidney Lee, London, 1891, Vol. XXVII. p. 217; Larousse, "Dict. Univ.," Vol. IX. pp. 934–935; Græsse (J. G. T.), "Trésor des livres rares," Vol. VI. pp. 209–211; "Biog. Gén.," Vol. XXVI. p. 555; Fabricius (Johann Albert), "Bibliotheca Latina Mediæ . . . Ætatis"; Delambre (J. B. J.), "Astron. du Moyen-Age," Vol. II; "Hist. Litter. de la France," Vol. XIX. p. 1; "Ency. Brit." ninth edition, Vol. XXI. pp. 140, 543.

Oribasius, SARDIANUS, was an eminent Greek physician, born about A.D. 325 at Sardes, the capital of Lydia. Gilbert (*De Magnete*, Book I. chap. i.) alludes to Chapter XIII of Oribasius' "De Facultate Metallicorum," which is embraced in one of the only three authentic treatises of his that have reached us, the first being part of a compilation relative to seventy medical books, whilst the second is a Synopsis, or rather an abridgment, of the first, and the third is called *Euporistes*, or manual of practical medicine.

REFERENCES.—"Dict. Hist. de la Médecine," par N. F. J. Eloy, Mons, 1778, Vol. III. 419–422; Eunapius, "Vitæ Philos. et Soph."; Sprengel (Kurt Polycarp Joachim), "Hist. de la Médecine"; "La Grande Encycl.," Vol. XXV. p. 561; "Biog. Gén.," Vol. XXXVIII. pp. 786–789; Fabricius (Johann Albert), "Bibliotheca Græca," Vols. IX. p. 451; XII. p. 640, and XIII. p. 353; Linden (Joannes Antonides van der) " . . . de scriptis medicis," Amst., 1651, pp. 476–477.

Orpheus, to whom Gilbert alludes (*De Magnete*, Book I. chap. ii.; Book II. chap. iii. and Book V. chap. xii.) is supposed to be the

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reproduced at pp. 1–26 of the "Rara Mathematica" of Jas. Orchard Halliwell, London, 1839.

The best commentary ever written on the astronomy of Sacro Bosco is the "Commentarius in sphæram . . . of Christopher Clavius," called the Euclid of his country. Clavius was born at Bamberg in 1538, died at Rome in 1612, and, according to Houzeau, was the author of as many as twenty-six different works on mathematics and astronomy. An almost equally valuable Commentary on the Sphere of Sacro Bosco was written by the famous encyclopedist Cecco d'Ascoli (1257–1327) whose real name, as we have already been informed, was Francesco degli Stabili (Libri, "Hist. des Sc. Mathém.," Vol. II. pp. 191–200, 525–526; Hœfer, "Hist. de l'Astronomie," Paris, 1873, p. 285; Alex. Chalmers, "Gen. Biog. Dict.," Vol. IX. pp. 1–3; Rose, "New Gen. Biog. Dict.," Vol. VI. p. 153; "Encycl. Brit.," 1876, Vol. V. p. 282; Bertelli, "Pietro Peregrino," 1868, p. 129).

Vedic Ribhu. Orpheus is a very important figure in Greek legend, whose existence is denied by Aristotle, but to whom are attributed many writings such as the *Argonautica, Lithica, Bacchica, Orphica,* etc.

REFERENCES.—" La Grande Encyclopédie," Vol. XXV. pp. 607–608; " Biog. Générale," Vol. XXXVIII. pp. 868–877; " English Cyclopædia," Vol. IV. pp. 592–593.

Oviedus, GONZALUS—Gonzalo Fernandez de Oviedo y Valdès—was one of the earliest historiographers of the New World (1478–1557), whose principal work—" Summario de las Indias Occidentales," printed 1525—Gilbert says (*De Magnete,* Book I. chap. i.) contains earliest mention of the fact that in the meridian of the Azores there is no variation.

REFERENCES.—The complete edition of Oviedus's writings which appeared in 1850; " Thesaurus Liter. Botanicæ," 1851, p. 218; Ticknor (George), " Hist. of Span. Lit.," 1849.

Parmenides, an ancient philosopher, native of Southern Italy, living in fifth century A.D., and the most prominent of the followers of the Eleatic School (founded by him and Xenophanes), has embodied a brief summary of his tenets in a work called " Nature," of which an able analyzation is to be found in the ninth " Encycl. Brit.," Vol. XVIII. pp. 315–317. Gilbert's only allusion to him is at Book V. chap. xii. of *De Magnete,* where he says that the ancient philosophers, as Thales, Heraclides, Anaxagoras, Archelaus, Pythagoras, Empedocles, Parmenides, Plato and the Platonists—nor Greek philosophers alone, but also the Egyptian and the Chaldean—all seek in the world a certain universal soul, and declare the whole world to be endowed with a soul.

Parmenides has also left fragments of a poem on astronomy which was published by Scaliger.

REFERENCES.—Ritter (Dr. Heinrich), " Hist. de la Philos." (tr. M. Tissot), Vol. I; Fabricius (Johann Albert), " Biblioth. Græca," Vol. I. p. 798; " Diog. Laert.," IX. 23; Houzeau et Lancaster, " Bibl. Gén.," Vol. II. p. 220; Larousse, " Dict. Univ.," Vol. XII. p. 307; " Biog. Gén.," Vol. XXXIX. pp. 227–230; Dr. Friedrich Ueberweg, " Hist. of Philosophy," New York, 1885, Vol. I. pp. 54–57; Paul Tannery, " Pour l'Histoire de la Science Hellène," Paris, 1887, Chap. IX. pp. 218–246.

Paulum Venetum. *See* Marco Polo, at A.D. 1271–1295.

Paulus Venetus. *See* Sarpi, Pietro at A.D. 1623.

Philolaus, the Pythagorean, was born at Crotona and flourished about 374 B.C. He was a disciple of Archytas, was the first known writer on the subject of physics, and it is said his writings were so highly esteemed that Plato employed three books of Philolaus for the composition of his " Timæus." Gilbert says (*De Magnete,*

Book VI. chap. iii.) that Philolaus, whom he calls an illustrious mathematician and a very experienced investigator of nature, would have the earth to be one of the stars and to turn in an oblique circle around the fire, just as the sun and moon have their paths.

In the "Abhandlungen zur Geschichte der Mathematik," Leipzig, 1899, Vol. IX. pp. 275–292, will be found "Note sur le charactère de l'astronomie Ancienne," by Paul Mansion, explaining the seven systems of Ancient Astronomy and showing the centre of the world to be, according to Philolaus, a central fire, or vital flame of the entire planetary system; whilst Eudoxus,[1] Ptolemæus and Tycho Brahé believed it to be the earth immovable; Heraclides of Pontus asserted that it was the earth rotating from West to East; and both Aristarchus and Copernicus maintained that it was the Sun.

REFERENCES.—Fabricius (Johann Albert), "Bibliotheca Græca"; Rose's "New Gen. Biog. Dict.," London, 1850, Vol. XI. p. 102; Houzeau et Lancaster, "Bibl. Gén.," Vol. II. p. 224; Chaignet (Antelme Edouard), "Pythagore et la Philosophie Pythagoricienne," 1873; Humboldt, "Cosmos," 1859, Vol. I. p. 65; Larousse, "Dict. Univ.," Vol. XII. p. 823.

Philostratus, FLAVIUS, to whom Gilbert alludes briefly at Chap. XXXVIII. book ii. of his *De Magnete* as affirming that the stone *pantarbes* attracts to itself other stones, was an eminent Greek sophist, born at Lemnos between 170 and 180 A.D., whose only writings known to us are accounts of the lives of Apollonius of Tyana [2] and of the Sophists. These were first published, Paris, 1608, and a part thereof have found a good translator in M. A. Chassang, who entitled his book "Le Merveilleux dans l'Antiquité," Paris, 1862.

REFERENCES.—Letronne (Jean Antoine), "Mém. de l'Acad. des Inscrip.," N. S., Vol. X. p. 296; Gibbon (Edward), "Roman Empire," Vol. III. p. 241; Ritter (Dr. Heinrich), "Hist. de la Philos. Ancienne," Vol. XII. chap. vii.; Fabricius (Johann Albert), "Bibliotheca Græca," Vol. V. p. 540; Miller, in the "Journal des Savants," 1849; "Biog. Gén.," Vol. XL. pp. 3–5; ninth "Encycl. Britan.," Vol. XVIII. pp. 796–797.

Plancius, PETER, who is alluded to in Edward Wright's address to Gilbert, was a Dutch theologian and astronomer—"a most diligent student, not so much of geography as of magnetic observa-

[1] Eudoxus, not before mentioned in this "Bibliographical History," was a native of Cnidus, Asia Minor, who flourished about 370 B.C. He was a pupil of Plato, and is frequently mentioned by Aratus, Archimedes, Aristotle, Cicero, Hipparchus, Proclus, Ptolemy, Seneca, Strabo, Vitruvius and others. Cicero calls him the greatest astronomer that has ever lived, and Strabo quotes him as a very distinguished mathematician.

[2] Apollonius of Tyana, a Pythagorean philosopher who lived in first century after Christ and who, in the account of his extraordinary travels through India, reports having seen the precious stone *pantarbes* casting rays of fire, and attracting all other gems, which adhered to it like swarms of bees ("Engl. Cycl.," Chas. Knight, Biography, Vol. I. p. 266).

tions "—(1552–1622), the first to recommend the Dutch expeditions to the Indies and who prepared the necessary instructions and maps to ensure their success. His universal map has been alluded to at the Blundeville entry, A.D. 1602. In the article on Dr. Kohl's Collection of Early Maps (" Harv. Univ. Bull.," Vol. III. p. 305) allusion is made to a map of America by Peter Plancius, 1594, which is spoken of by Blundeville in his " Exercises " as " lately put forth in the yeere of our Lord 1592."

REFERENCES.—Wagenaar (Jan), " Histoire de la Hollande," Vol. IX. p. 140, and also " Histoire d'Amsterdam," Vol. I. p. 407, and Vol. III. p. 219; " Biog. Gén.," Vol. XL. p. 403; Larousse, " Dict. Univ.," Vol. XII. p. 1129.

Plotinus of Alexandria, the father of Neoplatonism, lived 205–270 A.D. His writings were left to the editorial care of Porphyry, who arranged them in six divisions, each of which was subdivided into nine books, or Enneads. Plotinus maintains that men belong to two worlds, that of the senses and that of pure intelligence, and it depends upon ourselves as to which one we will direct most our thoughts and finally belong. The fire-firmament of Plotinus is alone referred to by Gilbert in the third chapter of the last book of *De Magnete.*

REFERENCES.—" Neoplatonism," and works cited in the Encyclopædias, also the works on Plotinus, especially by Kirchner (Carl), 1854, by Brenning (Emil), " Die Lehre . . . Plotin . . ." (1864), and by Kleist (E. C. von) (1884); Plotini, " Operum Philosophicorum Omnium," Basilæ, 1580, Liber III, Ennead II, p. 115; Kingsley (Charles), " Alexandria and her Schools," Camb., 1854; Grucker (Emile), " De Plotinianis," Paris, 1866; Lewes (George Henry), " History of Philosophy from Thales to Comte,"[1] London, 1867; Larousse, " Dict. Univ.," Vol. XII. p. 1198; " Biog. Gén.," Vol. XL. pp. 487–494; Dr. Fried. Ueberweg, " Hist. of Philos.," tr. of Geo. S. Morris, 1885, Vol. I. pp. 240–252; Bouillet (Marie Nicolas), " Les Ennéades de Plotin," 1857.

Ptolemæus, CLAUDIUS, the great Egyptian mathematician, geographer and astronomer who flourished in middle of the second century after Christ, is frequently alluded to throughout four of the books of *De Magnete,* and Gilbert makes direct reference to the " Opus Quadripartitum," " Cosmographia " and " Geographia." The last is, however, the work with which Ptolemy's name is most prominently connected. It was the standard up to the time of the marine discoveries of the fifteenth century, and has been translated and published into editions too numerous to mention here.

[1] Comte (Isidore Auguste Marie François-Xavier) (1798–1857). Very celebrated French philosopher, founder of Positivism, called Le Fondateur de la religion de l'humanité. Consult : Caird (Edward), " The Social Philosophy and Religion of Comte."

It may be added that the "Geographia Universalis" issue of 1540 is the first to embrace a proper map bearing the name "America," and that, to the identical account of Columbus which originally appeared in the 1522 and 1525 editions, Servetus appended a few words concerning the absurdity of putting the claims of Americus Vespuccius before those of the real discoverer.[1] The first book in which the name America was formally given to the new Continent is entitled "Globus Mundi," published 1507–1510, and attributed to Henricus Loritus—de Glaris—Glareanus. The suggestion of the name had, indeed, been made by the geographer Waldseemüller (Martinus Hylacomylus) of Freiburg, in his "Cosmographiæ Introductio," published at St. Dié, in Lorraine, April 25, 1507, but the "Globus Mundi" was first to put it into effect.

The Waldseemüller suggestion above alluded to is thus translated: "And the fourth part of the world, having been discovered by Americus, it may be called Amerige; that is, the land of Americus, or America." In 1901, Prof. Jos. Fischer, of Beldkirch, discovered, at Wolfegg Castle in Würtemberg, two huge maps, measuring together eight feet by four and a half feet, which proved to be those of Waldseemüller, of which all trace had been lost for centuries. They were reproduced in London, during the year 1903, and were thus alluded to by one of the writers at the time:

"Ever since Humboldt first called attention to the 'Cosmographiæ Introductio' no lost maps have ever been sought for so diligently as those of Waldseemüller. It is not too much to say that the honour of being their lucky discoverer has long been considered as the highest possible prize to be obtained amongst students in the field of ancient cartography. But until the summer of 1901, although many copies of the book are known in various editions, no specimen of either the globe or map has ever been seen or heard of in modern times. Some historians and geographers have even gone so far as to state definitely that they were never issued at all, and the book published alone. Others have held that they never got beyond their manuscript form, while some have contended that they were actually issued with the book, but, being separate, had become lost in the course of time. The writers holding this last view have been brought to their belief by tracing the supposed influence of the St. Dié cartography in later maps, and these authorities have been proved to be right by Prof. Fischer's discovery. The expectation that the missing map would be found to bear the name of

[1] With reference to the real discoverer, we can add here with propriety the words of John Fiske: "No ingenuity of argument can take from Columbus the glory of an achievement which has, and can have, no parallel in the whole career of mankind. It was a thing that could be done but once!"

AMERICA on the newly discovered Western Lands has also been duly realized."

References.—" Le nom d'Amérique et les grandes mappemondes . . . de 1507 et 1516," in " Annales de Géographie," 15 Janvier 1904, pp. 29–36; " History of North America," by Alfred Brittin, Philadelphia, 1903, at p. 293, Vol. I of which is a fine reproduction of a sheet from Waldseemüller's " Cosmographiæ Introductio " published in May 1507, showing the passage that first suggested calling the new world by the name of America; " Martinus Hylacomylus Waltzemüller, ses ouvrages et ses collaborateurs, par un géographe bibliophile " (M. d'Avezac), Paris, 1867; " Geographical Journal," Vol. XIX. pp. 201–209, 389; Humboldt, " Examen Critique," Paris, 1836, Vol. I. p. 22; also Vol. IV and Vol. V *passim*; " Amerigo Vespucci," Vol. II. pp. 129–179 of Justin Winsor's " Narrative and Critical History of America," Boston, 1889. See also the geography and maps of Loritus (Henricus), *Glareanus*, in the " Geographical Journal " for June 1905; " Le Journal des Savants " for December 1830; April and May 1831; August 1840; October and December 1843; July 1847; Houzeau et Lancaster, " Bibl. Gén.," Vol. I. part i. pp. 420–424, 684–688, and part. ii. p. 1390; also Vol. II. p. 231.

Puteanus, Guilielmus—Dupuis, and not Dupuy—French physician of the sixteenth century, professor at the University of Grenoble, is the author of " De Medicamentorum," Lyons, 1552, which was reproduced with a treatise of Cousinot under the title " De Occultis Pharmacorum " two years later. To Puteanus, Gilbert alludes (*De Magnete,* Book I. chap. i. and Book II. chap. iii.) saying that he discusses the loadstone briefly and crudely and deduces its power, not from a property of its whole substance unknown to any one and incapable of demonstration (as Galen held and, after him, nearly all physicians), but from " its substantial form as from a prime motor and self-motor, and as from its own most potent nature and its natural temperament, as the instrument which the efficient form of its substance, or the second cause, which is without a medium, employs in its operations. So the loadstone attracts iron not without a physical cause, and for the sake of some good." But nothing like this, adds Gilbert, is done in other bodies by any substantial form unless it be the primary one, and this Puteanus does not recognize.

References.—" Biographie Générale," Vol. XV. p. 367; Larousse, " Dict. Universel," Vol. VI. p. 1420.

Pythagoras, celebrated Greek philosopher (569–470 B.C.) who, as Hegel says, " First made thought and not sense the criterion of the essence of things." He is said to have travelled widely and, according to one of his biographers, he learned geometry from the Egyptians, arithmetic from the Phœnicians, astronomy from the Chaldæans, religious formulæ and ethical maxims from the Magians, and obtained other scientific and religious knowledge from the Arabians and the Indians. He settled finally at Crotona in Lower

Italy, during the year 529 B.C. and there established the school that has made him famous.

To a complete exposition of the Pythagorean school or sect, the "Biographie Générale" devotes, in Vol. XLI, twenty-four full columns, whilst the notices of the Pythagoreans which Aristotle gives in the first book of the "Metaphysics" contain about all that is of importance in their theory.

According to the report of Philolaus of Croton, the Pythagoreans taught the progressive movement of the non-rotating Earth, its revolution around the focus of the world (the central fire, *hestia*), while Plato and Aristotle imagined that the Earth neither rotated nor advanced in space, but that, fixed to one central point, it merely oscillated from one side to the other. Humboldt, from whose "Cosmos" the above is taken, further says that the figurative and poetical myths of the Pythagorean and Platonic pictures of the universe were as changeable as the fancy from which they emanated, and he cites Plato, who, in the *Phædrus*, adopts the system of Philolaus, whilst, in the *Timæus*, he accepts the system according to which the earth is immovable in the centre and which was subsequently called the Hipparchian or Ptolemaic.[1]

REFERENCES.—Ueberweg (Dr. Friedrich), "History of Philosophy," tr. of Geo. S. Morris, New York, 1885, Vol. I. pp. 42–49; Butler (William Archer), "Lectures on Ancient Philosophy"; Gilbert, *De Magnete*, Book II. chap. ii., and Book V. chap. xii.; Chas. Rollin, "Ancient History," London, 1845, Vol. I. pp. 383–384; Iamblichus' "Life of Pythagoras," translated from the Greek by Thos. Taylor; "Dict. des Sc. Philos.," Paris, 1852, Vol. V. pp. 297–312; Ritter (Dr. Heinrich), "History of Ancient Philosophy," London, 1846, Vol. I. pp. 326–357; Houzeau et Lancaster, "Bibl. Gén.," Vol. II. p. 232; Roeth (Eduard), "Geschichte," 1846–1858; Cantor (Moritz), "Geschichte der Mathematik," Leipzig, 1894, Vol. I. pp. 137–201; Grote (George), "Greece," Vol. IV. pp. 525–551; Chaignet (Antelme Edouard), "Pythag. et la Phil. Pyth.," 1873.

Reinholdus, ERASMUS. *See* Erasmus.

Rhazès—Razes—Rasis—Rasaeus—Abu-Bekr Al-Rázi—Muhammad Ibn Zakariya—one of the most famous of the ancient Arabian

[1] " . . . Aristotle adds that some say the earth being situated in the centre, is rolled around the pole, as it is written in the *Timæus* . . . there are three significations of the pole with Plato. Thus, in the *Phædo*, he calls heaven the pole, and also the extremities of the axis about which the heaven revolves. But, in other places of the *Timæus*, and also in the present passage he calls the axis the pole" ("The Treatises of Aristotle," Thos. Taylor, London, 1807, p. 235; Humboldt, "Cosmos," 1849, Vol. II. p. 695, note). The Earth "is said by Plato to be conglobed about the pole, which is extended through the universe; because she (the Earth) is contained and compressed about its axis. For the axis also is the pole. And the pole is thus now denominated because the universe revolves about it . . . on this account, the pole is said by Plato to be extended through the universe, as entirely pervading the centre of the Earth" ("The Six Books of Proclus," Thos. Taylor, London, 1816, Book VII. chap. xxii. pp. 172–173).

physicians, is the author of "De simplicibus, ad Almansorem," the ten books of which contain a complete system of medicine.[1] In Book I. chap. xv. of *De Magnete*, reference is made to Chap. LXIII. liber ix. of Rhazès' work, entitled "De Curatione omnium partium," wherein an electuary of iron slag, or of prepared steel filings, is spoken of as a highly commended and celebrated remedy for dried-up liver, the Arabs believing that iron opens the spleen and the liver.

REFERENCES.—"Journal des Sçavans," Vol. LXXVI for 1725, p. 220, and Vol. LXXXV for 1728, p. 412; "Journal des Savants" for February 1892, pp. 118–126 *passim*, and for March 1892 ("l'Alchimie de Razes"), pp. 190–195, also for May 1851, p. 288, giving names of all the leading alchemists; "Abhandlungen zur Geschichte der Mathematik," Vol. VI., Leipzig, 1892, pp. 43–44, 76; Larousse, "Dict. Univ.," Vol. XIII. p. 747; Freind (John), "History of Physic"; Eloy (N. F. J.), "Dict. Hist. de la Médecine," Vol. IV. pp. 56–61; Haller (Albrecht von), "Bibliotheca Botanica"; Sprengel (Kurt Polycarp Joachim), "Hist. de la Médecine."

Ruellius, JOANNES—Jean Ruel—(1479–1537), was a French physician, attached to the court of François I--, who wrote a Commentary on Dioscorides, published 1516, 1529, 1543, as well as several medical treatises. The one by which he is best known is the "De Natura Stirpium," Paris, 1536, reprinted four times at Basle and at Venice, from which Gilbert extracts (*De Magnete*, Book I. chap. i.) the mention by Ruellius that the loadstone's force, when failing or dulled, is restored by the blood of a buck.

REFERENCES.—"Sc. de Ste Marthe, Elogia Doct. Gallorum"; Eloy (N. F. J.), "Dict. hist. de la Méd."; "Biographie Générale," Vol. XLII. pp. 864–865.

Rueus, FRANCISCUS—François de la Rüe—(1520–1585), Flemish naturalist who long practised in his native country and the author of "De Gemmis aliquot . . ." 1547, 1565, which was printed, with the book on "Philosophy of Vallesius" in 1588, 1595, 1652, also at Franckfort in 1596, and together with the "Similitudines ac Parabolæ" of Lev. Lemnius in 1626. Gilbert's only reference to him is briefly made in the opening chapter of *De Magnete*.

REFERENCES.—Valère, André, "Bibl. Belgica," p. 240; Mercklein (Georg Abraham), "Lindenius renovatus," 1686, pp. 297, 304; Le P. Lelong, "Bibl. Sacr.," p. 935; "Biog. Générale," Vol. XXIX. p. 702.

Scaliger, JULIUS CÆSAR (1484–1558), a famous Italian scholar who practised medicine at Verona until 1525 and afterwards de-

[1] It was for a copy of the valuable works of this popular Arabian physician, which he borrowed from "La Faculté de Médecine" of Paris, that Louis XI had to deposit in pledge a large quantity of plate and had, besides, to procure a nobleman to join him as surety in a Deed binding himself under great forfeiture to restore these extraordinarily scarce books (Gabr. Naudé, "Additions à l'histoire de Louis XI," par Comines, Vol. IV. p. 281). Rhazès was born and brought up at Rai, the most northern town of Irak Ajemi, where he is said to have died A.D. 923 or 932 ("Engl. Cycl.," Vol. V. pp. 69–70).

voted his time to writing on various subjects, as shown in the "Biographie Générale," Vol. XLIII. pp. 446–450. Of the works cited in latter, should be extracted, as best known: "In Aristotelis . . . de plantis," 1556; "In Theophrasti, de causis plantarum," 1566; "De Subtilitate ad Cardanum," 1557, 1560, 1576, 1592, 1634.

It is to the last-named important work that Gilbert frequently alludes (*De Magnete*, Book I. chaps. i. xvi; Book II. chaps. i. iii. iv. xxxviii.; Book iv. chap. i.). He says, more particularly, that Scaliger strays far from truth when, in treating of magnetic bodies, he speaks of diamond attracting iron, also that he keeps the loadstone and iron in bran to protect them from the injurious action of the atmosphere, and that Scaliger, in order to explain the difference of variation for change of locality, brings in a celestial cause to himself unknown, and terrestrial loadstones that have nowhere been discovered; and seeks the cause not in the "siderite mountains," but in that force which formed them, to wit, in the part of the heaven which overhangs that northern point.

References.—Teissier (H. A.), "Eloges des hommes illustres"; Coupé (Jean Marie Louis), "Soirées littéraires," Vol. XV; Nicéron (Jean Pierre), "Mémoires," XXIII; Larousse, "Dict. Univ.," Vol. VIII. pp. 692–693.

Silvaticus—Sylvaticus—Matthæus Moretus, well-known Italian savant living in 1344, physician to the King of Naples, one of the professors at Salerno,[1] and author of "Matth. Silvatici, medic. de Salerno, Liber cibalis et Medicinalis Pandectarum . . ." originally published at Naples, 1474. This work, dedicated to Ferdinand, King of Sicily, is an Encyclopædic Dictionary and one of the most important books we have of the history of medicine in the Middle Ages, and at beginning of the Italian Renaissance. The citations made by Græsse ("Trésor," Vol. VI. p. 406), state that Silvaticus was the owner of a private botanical garden at Salerno (Chap. CXCVII. s.v. "Colcasia" of the Opus Pandectarum), and allude to Thos. Frognall Dibdin's "Bibliotheca Spenceriana," Vol. IV. London, 1815, pp. 24–25, and Van der Meersch, "Rech. sur les impr. Belges," etc., Vol. I. pp. 384, etc.

[1] The School of Salerno and the introduction of Arabian sciences into Italy are discussed with learning and judgment by Muratori (Lodovico Antonio), "Antiquitates Italiæ Medii Aevi.," Vol. III. pp. 932–940, and by Giannone (Pietro), "Istoria Civile del Regno di Napoli," Vol. II. pp. 119–127). Consult, likewise, for the Salerno school, "Universities of Europe in the Middle Ages," by Hastings Rashdall, Oxford, 1895, Chap. III. pp. 75–86, and also pp. 306–307, Vol. IV. part i. of the "History of the City of Rome in the Middle Ages . . ." of Ferdinand Gregorovius, tr. by Annie Hamilton, London, 1896.

REFERENCES.—"Repertoire et sources historiques du Moyen Age," par l'abbé Ulysse, Joseph Chevalier, Paris, 1877–1886, p. 2089; Argellati (Philippo), "Bibliotheca Mediolan.," 1745; Tiraboschi (Girolamo), "Storia della Letteratura Italiana," 1807, Vol. I. p. 275; Sbaralea (Joannes Hyacinthus), "Supplementum . . . Scriptores ordinis," 1806, p. 529; Tafuri (Giovanni Bernardino), "Scrittori . . . di Napoli," 1749, Vol. II. pp. 67–70; "Thesaur. Lit. Bot.," 1851, p. 185; Brunet (Jacques Charles), "Manuel du Libraire," 1864, Vol. V. pp. 387–388; Watt (Rob.), "Bibliotheca Britannica," Edinburgh, 1824, Vol. II. p. 856 *h*; Larousse, "Dict. Univ.," Vol. XIV. p. 1308; Paul Lacroix, "Science and Literature of the Middle Ages," p. 117; Ludovico Hain, "Repertorium Bibliographicorum," Vol. II. part ii. Nos. 15192–15202, pp. 375–376; Gilbert, *De Magnete*, Book I. chap. i.

Solinus, CAIUS JULIUS—*Grammaticus*—a Roman writer who lived in latter part of the second century, the author of a compilation in fifty-seven chapters which contains a sketch of the world as it was known to him, but which is supposed to have been taken entirely from Pliny's "Natural History." It was originally published under the title of "Collectanea rerum mirabilium," the second edition being headed "Polyhistor." This was one of the earliest known printed books, having first appeared at Venice in 1473, and it has since been translated into many foreign languages, notably during 1600, 1603, and 1847.

The most important of the three references Gilbert makes to Solinus is found in *De Magnete*, Book II. chap. xxxviii., where it is said that Pliny and Julius Solinus tell of the stone *cathochites*, affirming that it attracts flesh and that it holds one's hand, as loadstone holds iron and amber holds chaff. But that, says he, is due solely to its viscosity and its natural glutinousness, for it adheres most readily to a warm hand.

REFERENCES.—Dodwell (Henry, the elder), "Dissertationes Cyprianicæ"; Moller (D. W.); C. J. Solino, in "Biog. Gén.," Vol. XLIV. pp. 153–154; "La Grande Encycl.," Vol. XXX. p. 232.

Thebit Ben-Kora—Thabit Ibn Corrah—Abū Thabit Ibn Kurrah—Tebioth ben Chorezen (Houzeau, No. 1130), one of the most brilliant and accomplished scholars produced by the Arabs (836–901), called by Delambre "Le Ronsard de l'Astronomie," is the author of many treatises on mathematics, and on other scientific subjects, the mention of the titles of which take up nearly two folio pages of Casiri's "Catalogue." Especially is he shown in latter as having translated into Arabic the chief works of Archimedes, Apollonius, Euclid and Ptolemy also the Physics and Analytics of Aristotle and many of the works of Hippocrates and Galen.

Incidentally it may be added that geometry, to which Thebit Ben-Kora gave particular attention, was named by the Arabs *handassah*, and that the *Tahrir Hendassiat* contains: the explication,

the *data* and the optics, of Euclid, the *syntaxis magna* of Ptolemy, the spherics of Theodosius and his book concerning night and day, the spherics of Menelaus, the movable sphere of Autolycus, the *ascendants* or *horoscopes* of Asclepius, a treatise of Aristarchus on the discs of the sun and moon, the *lemmas* or theorems of Archimedes, also his treatise on the sphere and cylinder, the conics of Apollonius and Thebit Ben-Kora, a treatise of Theodosius on the positions, or quiescence, of bodies, etc., etc. (D'Herbelot, art. *Handassah,* and *Aklides.* See also, for origin of geometry, etc. "A Short History of Greek Mathem.," Jas. Gow, Cambridge, 1884, pp. 123–134.)

The allusions by Gilbert are to be found, Book III. chap. i., and Book VI. chap. ix. of *De Magnete,* in which latter it is said that, Thebitius, in order to establish a law for the great inequalities in the movements of the stars, held that the eighth sphere does not advance by continued motion from west to east, but that it has a sort of tremulous motion, "a movement of trepidation."

References.—"Hist. de la Médecine Arabe," par Dr. Lucien Leclerc, Paris, 1876, Vol. I. pp. 168–172; Dreyer (J.), "Tycho Brahe," 1890, pp. 354–356; Houzeau et Lancaster, "Bibl. Gén.," Vol. I. part i. pp. 466–467, 702; "History of Mathematics," Walter W. Rouse Ball, London, 1888, p. 153; "Abhandlungen zur Geschichte der Mathematik," Vol. VI, Leipzig, 1892, pp. 25–26.

Themistius of Paphlagonia—surnamed Euphrades—was a distinguished Greek orator and writer (about 315–390), whose philosophical works consist of commentaries in the form of paraphrases on some of Aristotle's writings, one being upon the work "On Heaven," and the other upon the twelfth book of the "Metaphysics." The paraphrases were first published by Hermolaus Barbarus in 1481. Gilbert's only reference is briefly made in *De Magnete,* Book II. chap. iv.

References.—Schöll (Carl), "Geschichte d. G. Litt.," Vol. III. pp. 96, 388, or "Hist. de la Litt. Grecque," Vol. VI. p. 141; Vol. VII. p. 121; Photius, *cod.* LXXIV; Fleury, "Hist. Eccles."; Tillemont, "Hist. des Emp.," Vols. IV and V; Suidas, art. "Themistius"; E. Baret, "De Themistio sophista . . ." Paris, 1853; Brucker, "Hist. Crit. de la Phil.," Vol. II. p. 484.

Zoroaster—Zarath 'ustra—Zerdusht—founder of the religious system contained in the Zend-Avesta (religious book of the Parsees, fire worshippers), is said to have been a native of Bactria, near the modern Balkh, and to have lived about 589–513 B.C. That he was an historical personage, equally with Buddha, Confucius and Mahomet, it is now scarcely possible to doubt.

His able biographer in the English Cyclopædia, London, 1868, Vol. VI. pp. 946–948, states that Zoroaster was a great astrologer and magician, and it is said at p. 95 of Mr. A. V. W. Jackson's

admirable work on Zoroaster, published in New York, 1899, that some of the original Nasks of the Avesta are reported to have been wholly scientific in their contents, and that the Greeks even speak of books purported to be by Zoroaster treating of physics, of the stars and of precious stones.

Zoroaster is merely named by Gilbert in manner shown at the Hermes Trismegistus entry.

References.—" Life of Zoroaster," prefixed to Anquetil du Perron's " Zend-Avesta," Paris, 1771; Pastoret (Claude Emmanuel J. P. de), " Zoroaster, Confucius et Mahomet comparés," 1787; Hyde (Thomas), " Historia . . . Veterum Persarum . . ." Oxford, 1760; " Zend-Avesta, Ouvrage de Zoroastre," 2 vols. Paris, 1771; Martin-Haug (I.), " Essays," Bombay, 1862; Malcolm (Sir John), " History of Persia," 1815; Darmesteter, " Ormazd et Ahriman," Paris, 1877; Spiegel (Friedrich), " Erânische Alterthumskunde," Leipzig, 1871–1878; Chas. Rollin, " Ancient History," London, 1845, Vol. I. pp. 234–235, 237; Ritter (Dr. Heinrich), " History of Ancient Philosophy," London, 1846, Vol. I. p. 52; " History of the Decline and Fall of the Roman Empire," Edward Gibbon (Milman), Philad., 1880, Vol. I. pp. 229–230, notes, and, for abridgment of his theology, pp. 231–234; also the Bury ed., London, 1900, Vol. I. pp. 197–198, 456–457; Vol. V. p. 487; " Classical Studies in Honour of Hy. Drisler," New York, 1894, pp. 24–51; " The Fragments of the Persika of Ktesias," by John Gilmore, London, 1888, pp. 29–36, 95; " The Great Monarchies of the Ancient Western World," by Geo. Rawlinson, London, 1865, Vol. I. p. 195; Vol. III. pp. 93, 98, 105, 127, 135–139, 164; Vol. IV. pp. 110, 333; " Essai Historique," Eug. Salverte, Paris, 1824, Vol. II. p. 503.

To the foregoing " Accounts of Early Writers," can properly be added the following happy description of " The School of Athens," [1] as coloured by Raphael and now to be seen among his frescoes in the papal state-apartments (*Stanze—Camere*) of the Vatican in Rome, for, it will be observed, most of the leading writers of which we have spoken are therein depicted :

" The School of Athens "—*Scuola d'Atene*—represents Philosophy in general, and is, with regard to expression and scholastic knowledge, a wonderful work; for every philosopher, by his posture and gestures, characterises his doctrines and opinions. . . . Beginning with the Ionian School, on the right, before the statue of Minerva, the aged person whose head is covered with linen, after the Egyptian manner is Thales; whom Raphael has represented as walking with a Stick, because, with that, he measured the Pyramids. Next to Thales is Archelaus of Messenia. . . . Behind them is Anaxagoras, resting his foot upon a marble book and almost hidden; in reference to the persecutions he underwent. The next figure, standing alone, at a little distance, to show that he is of another School, represents Pythagoras; who seems resolved to continue fixed at one spot, to

[1] Extracted from " Information and Directions for Travellers," by Mariana Starke, 8th ed., John Murray, London, 1832.

show the unchangeableness of his ideas . . . his head and body being turned different ways shows his metaphorical method of teaching important truths; and the crown, formed by his hair, refers to his initiation in all mysteries. The Figure leaning on a column is Parmenides; close to whom sits a youth, his adopted son Zeno, who is writing something short; referring to a Poem, by Parmenides, which compared, in two hundred lines, all the various Systems of Philosophy. Two masters only of the Eleatic School are introduced; because its followers were few in number. The metaphysics of Parmenides and Zeno gave rise to the Sceptical Philosophy of Pyrrho, expressed by the next figure. . . . At the opposite side of the Picture, talking with his fingers to a Figure in armour, supposed to represent Alcibiades, is Socrates . . . who, like Thales, appears to be walking; because geometry was never taught in a fixed place. . . . Plato and Aristotle are placed together on a flight of steps in the centre of the Picture: Plato, representative of the speculative school, holds the Timæus: his sublime style is expressed by his attitude, denoting that his thoughts soar above this earth; and the cord attached to his neck marks his initiation at the Eleusinian Mysteries. . . . Aristotle, founder of ethical and physical philosophy, points earthward. The Figure in shade, nearest to Plato, is Archothæa. . . . The next Figure, in the same line, indicates roughness of character, and represents Xenocrates. . . . Behind Socrates and another Figure, Lasthenia, is a bearded old man Zeno of Citium, the founder of the sect called Stoics. . . . Behind Zeno of Citium is Antisthenes, in shade, because his School is expressed by that of Zeno. On the side of Aristotle, the tallest and most conspicuous Figure is Theophrastus . . . said to be the portrait of Cardinal Bembo. The next figures are Strato of Lampsacus, Demetrius Phalereus, Callisthenes, Neophron, Glycon. Behind the last named is Heraclides and in rear of the disciples of Aristotle are Euclid of Megara and Eubulides of Miletus, his pupil: the last hated Aristotle, and is looking angrily at him. The lower part of the Picture, on the side with the statue of Apollo, represents the Philosophy of Leucippus, the disciple of Zeno, though the author of a very opposite system. He first taught the doctrine of Atoms. . . . Democritus, his most celebrated disciple, is sitting near him—booted, in the manner of his countrymen, the Abderites—and writing upon a stone table, shaped like the sacrophagi among which he used to meditate: he lost his fortune, therefore his dress indicates poverty; and he is represented in deep meditation, to show his uncommon studiousness. Opposite to Leucippus sits Empedocles, resting on a *cube*, though not with *contempt*, according to the principles of Leucippus; because Empe-

docles adhered, on some points, to the Pythagorean system. The youth holding, before Empedocles, Pythagoras's Table of the Generation of Numbers and the Harmonies, is Meton. . . . The Figure in an Oriental costume bending over Pythagoras, represents Averrhoes, or one of the Magi, from which sect the Grecian Schools derived part of their doctrines. Behind Empedocles, is Epicharmus. . . . The Figure in a toga is Lucretius, placed near Empedocles, as having been his follower; but looking another way, because he differed from his master. This figure is the portrait of Francesco, Duke of Urbino, nephew to Julius II. The person crowned with vine-leaves and resting a book on a pedestal, is Epicurus, looking gay, according to the account given of him, and the Figure leaning upon his shoulder is Metrodorus; next to whom is Heraclitus, wearing a black veil, like that of the Ephesian Diana, in whose temple he exposed his works. Seated on the second step, near the centre of the Picture, is Diogenes, and below him is a Portrait of the great architect, Bramante (under the character of Archimedes), who is tracing an hexagonal figure on the pavement . . . the enthusiastic-looking person who points to the hexagon, is supposed to be Archytas of Tarentum; the boy on his knees, is Phenix of Alexandria; and behind him, with a hand on his back, is Ctesibius. In the angle of the picture are Zoroaster and Ptolemy, one holding a celestial and the other a terrestrial globe, as representatives of Astronomy and Geometry; the figure wearing a crown, under the character of Zoroaster, being Alphonso, King of Arragon, Sicily and Naples; the person with a black turban on his head, and likewise holding a Globe, may probably represent Confucius: and the two persons with whom Alphonso seems conversing are portraits of Raphael and of his master Pietro Perugino. The statues and *bassi-relievi* with which Raphael has ornamented his scene, are emblematical of the different Schools of Philosophy: and the picture, in point of composition, is considered to be his *chef-d'œuvre*, the Sibyls of S^a Maria della Pace excepted.

A more detailed description of the above will be found in the works of Trendelenburg (Berlin, 1843), and of Richter (Heidelberg, 1882), bearing title "Ueber Rafael's Schule von Athen."

APPENDIX II

DISCOVERIES MADE BY WILLIAM GILBERT—DESIGNATED IN "DE MAGNETE" BY THE LARGER ASTERISKS

(*Alluded to in the Gilbert* A.D. 1600 *Article, p.* 83)

Book I. chap. iii. The loadstone ever has and ever shows its poles, which look toward the poles of the earth and move toward them and are subject to them.

Book I. chap. vi. The loadstone attracts iron ore, as well as the smelted metal, the best iron, *acies*, being the most readily attracted.

Book I. chap. ix. Iron ore attracts iron ore.

Book I. chap. x. Iron ore has and acquires poles, and arranges itself with reference to the earth's poles.

Book I. chap. xi. Wrought-iron, not magnetized by the loadstone, attracts iron.

Book I. chap. xii. A long piece of iron, even not magnetized, assumes a north and south direction.

Book I. chap. xiii. Smelted iron has in itself fixed north and south parts, magnetic activity, verticity, and fixed vertices or poles.

Book II. chap. ii. Not only do amber and jet attract light substances: the same is done by the diamond. . . .

Book II. chap. ii. When the atmosphere is very cold and clear, the electrical effluvia of the earth offer less impediment.

Book II. chap. xxv. A strong, large, loadstone increases the power of another loadstone, and also the power of iron.

Book II. chap. xxxiv. Why a loadstone is of different power in its poles as well in the north as in the south regions (two experiments).

Book III. chap. xii. Iron becomes magnetized when red-hot and hammered in the magnetic meridian; also when the iron bars have, for a long time, lain fixed likewise in the north and south position (two experiments).

Book III. chap. xv. Two more experiments to show that the poles, equator, centre, are permanent and stable in the unbroken

loadstone; when it is reduced in size and a part taken away, they vary and occupy their positions.

Book IV. chap. ii. Variation is due to inequality among the earth's elevations.

Book V. chap. ii. Illustration of the direction and dip of a *terrella* representing the earth relative to the standard representation of the globe of the earth, at north latitude 50°.

Book V. chap. iii. Instrument for showing by the action of a loadstone, the degree of dip below the horizon in any latitude.

Book V. chap. vi. Of the ratio of dip to latitude and the cause thereof.

Book V. chap. xi. Of the formal magnetical act spherically effused.

APPENDIX III

THE PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY OF LONDON

Unabridged

Commenced in 1665, as a periodical, by H. Oldenberg, first Secretary of the Society, and continued by him up to June 1677. Afterwards, successively edited by N. Grew, R. Plot, W. Musgrave, R. Walker, Sir H. Sloane, E. Halley, C. Mortimer, and other Secretaries, up to March 1752, when the publication began to be superintended by a Committee of the Royal Society. From 1665 to 1678, the publication was regularly made, with exception of six months between 1677 and 1678.

The title-page, "Philosophical Transactions giving some account of the present undertakings, studies and labours of the Ingenious in many considerable parts of the world," was maintained up to the sixty-sixth volume, for year 1776, when it gave place to "The Philosophical Transactions of the Royal Society of London."

From 1679 to 1682, no volumes appeared, the lacunæ being (partly) made up through the seven numbers of "Philosophical Collections" issued by Robert Hooke (Nos. 1–7, one volume 4to).

From 1683 to the present time, the publication has gone on uniformly, with exception of years 1688–1690, during which nothing was published, and of years 1691–1692, the proceedings of which appear in a volume (sometimes marked Vol. 16 and sometimes Vol. 17), containing the numbers 192–195.

Reference to "The Bibliographer's Manual," by Wm. Thomas Lowndes (London, 1863, Part VIII. pp. 2143–2146) and to Samuel H. Scudder's "Catalogue of Scientific Serials" (Cambridge, Mass., 1879, p. 27) will show how the different unabridged volumes have been made up, viz. Vols. 1–65 cover the years 1665–1775; Vols. 66–81 cover the years 1776–1791; Vols. 82–142 cover the years 1792–1852; Vols. 143–166 cover the years 1853–1876.

Regular dates followed up to Vol. 177, issued 1886–1887, since

when the publication has appeared in two series, viz. A (Physical) and B (Biological). The volumes now running are A 220, B 210.

In addition to the above, there have appeared, amongst many publications :

" A General Index . . . to all the Philosophical Transactions from the beginning to July 1677," London, 1678.

" A General Index . . . from January 1667–1668 to December 1693," London, 1694. And one by James Briggs, 1665–1817.

" A General Index to the Philosophical Transactions from the first to the end of the seventieth volume," by Paul Henry Maty (viz. 1665–1780, which was continued for 1781–1820 as Part II and for 1821–1830 as Part III).

" Index to Volumes 1–17 " (London, 1787) ; " Index to Volumes 71–110 " (London, 1821) ; " Index for years 1821–1830 " (London, 1833) ; " Index to Volumes 1–120 " (London, 1842).

" Supplement to the Philosophical Transactions of July 1670 " (by W. Holder), London, 1678.

" Supplement to the Philosophical Transactions for October 1702 " (by M. Lister), London, 1702.

" Miscellanea Curiosa . . . being the most valuable discourses read and delivered to the Royal Society," 3 Vols., London, 1723-1727.

" Abstracts of the Papers printed in the Philosophical Transactions " : 1800–1830, Vols. I–II ; 1831–1843, Vols. III–IV ; 1843–1850, Vol. V ; 1850–1854, Vol. VI. From Vol. VI, continued as the " Proceedings of the Royal Society," the years 1854–1905 being represented by Vols. VII–LXXVI (issued, from this date onward, in two series (A, Physical, and B, Biological) ; about two volumes each year).

" Catalogue of Scientific Papers. Compiled and published by the Royal Society of London " : 1800–1863, A to Z, Vols. 1–6 ; 1864–1873, A to Z, Vols. 7–8 ; 1874–1883, A to Z, Vols. 9–11 ; 1800–1883, A to Z, Vol. 12 ; 1884–1900, A to B, Vol. 13, reaching Vol. 17 in 1920.

Four volumes of Subject Index to the above have appeared, treating of Pure Mathematics, Mechanics, Heat, Light and Sound, Electricity and Magnetism.

Abridged

The several Abridgments may be properly collated as follows (through Lowndes, Scudder, Bolton, also through the private lists of the different copies found in Hartwell House, November 1843, and given to the compiler by Mr. Latimer Clark), viz. : From 1665 to

end of 1700, by John Lowthorp, 3 vols., Vols. I, II, III [1]; from 1700 to year 1720–1721 by Ben. Motte, 2 vols. [2]; from 1700 to year 1720 by Henry Jones, 2 vols., Vols. IV, V [3]; from 1720 to year 1732 by Mr. Reid and John Gray, 1 vol. [4]; from 1719 to year 1733, by John Eames and John Martyn, 2 vols., Vols. VI, VII [5]; from 1732 to year 1744, by John Martyn, 2 vols., Vols. VIII, IX [6]; from 1743 to year 1750, by John Martyn, 2 vols., Vol. X (two parts).

"Memoirs of the Royal Society; or a New Abridgment of the Philosophical Transactions from 1665 to 1740," by Benjamin Baddam, 10 Vols. (first edition, 1665–1735; second edition, 1665–1740).

"The Philosophical Transactions from their commencement in 1665 to 1800 abridged with notes and illustrations, by Charles Hutton, George Shaw and Richard Pearson," 18 vols., the last volume containing a General Index to the whole which covers 116 pages.[7]

Translations, in French, of some of the abridged and unabridged volumes are to be found recorded at p. 109 of Scudder's "Catalogue," already mentioned, one of the most important being "La Table des mémoires imprimés dans les Transactions Philosophiques . . . 1665–1735," by M. De Brémond, Paris, 1739.

Translations have also been made in Latin, for the first five years, and some were published in Italian during 1729 and 1731–1734.

THE PHILOSOPHICAL MAGAZINE

The Philosophical Magazine, 1798–1813, 42 vols. United in 1814 with the Journal of Natural Philosophy, etc., and continued under the title of

[1] Vol. III has at p. 688 an Index and an advertisement to the effect that two more volumes by Benjamin Motte will continue the work from 1700 to 1720.

[2] Benjamin Motte edited in 1721 an abridgment 1700–1720, in three volumes which "was very incorrect and was severely handled by a rival editor, Hy. Jones, fellow of King's College, Cambridge" ("Dict. of Nat. Biogr.," Vol. XXXIX. p. 194).

[3] These volumes, IV and V, are generally adopted, instead of those by Benjamin Motte, "a printer who had issued a bad abridgment of the same portion" before that of Henry Jones ("Dict. Nat. Biogr.," Vol. XXX. p. 109).

[4] This volume is in two parts, separately paged, and is by some designated as the volume VI to take the place of one of those of Eames and Martyn.

[5] Volume VII is followed by an Index to the previous seven volumes.

[6] John Martyn published, between 1734 and 1756, five volumes comprising the Transactions from 1719 to 1750 ("Dict. of Nat. Biogr.," Vol. XXXVI. p. 318). The last two volumes are marked Vol. X. parts i. and ii.

[7] Hutton's Abridgment contains . . . many biographical memoirs of deceased members of the Royal Society, as well as some rare tracts not readily found elsewhere.

The Philosophical Magazine and Journal, etc., 1814–1826, 26 vols., the sixty-eight volumes being called the first series. During 1827 it was united with the Annals of Philosophy or Magazine of Chemistry and it became then

The Philosophical Magazine or Annals of Chemistry, etc., 1827–1832, eleven vols., making up the second series. From 1832 to 1840, after amalgamating with Edinburgh Journal of Science, sixteen volumes were published under the name of

The London and Edinburgh Philosophical Magazine and Journal of Science, and, during 1840–1850, twenty-one volumes appeared under the name of

The London, Edinburgh and Dublin Philosophical Magazine and Journal of Science, in all thirty-seven volumes constituting the third series. The fourth series, of fifty volumes, was issued 1851–1875; the fifth series 1876–1900; and the sixth series, which began in 1901, is still running as we go to press.

LE JOURNAL DES SÇAVANS (SAVANTS)

Le Journal des Sçavans (Scudder, "Catal. of Sc. Serials," 1879, p. 97). Published 1665–1792, with Supplements to 1707–1709 and a *Continuation* in 1797.

Journal des Sçavans ("Catal. of Ronalds' library," 1880, p. 261). Published 1665–1748, 1749–1792, 1816–1845.

Le Journal des Sçavans ("British Museum Catalogue of Periodical Publications—Paris," pp. 1369–1370). Published from 1665 to 1828. Edited successively by the Sieur de Hedonville, by J. Gallois, and others. With a Supplement for 1672–1674, and a Supplement for each of the years 1707, 1708 and 1709—142 volumes, Paris, 1681–1828, also 1723.

The "Journal des Sçavans" was commenced January 5, 1665, and suppressed March 30, 1665, after the publication of only thirteen numbers. Its publication was resumed January 4, 1666, during which year forty-two numbers were issued. In 1667, there appeared only sixteen numbers; only thirteen in 1668; four in 1669; one in 1670; three in 1671; eight in 1672; none in 1673; and only two in 1674. From 1674 to 1723, a number was published either once a fortnight or once a week, and, from 1724 to 1792, a number appeared every month. In December 1792, the publication was discontinued, but it was resumed January 4, 1797. On the 18th of June of the same year, however, it was again discontinued until September 1816, after which a number was for a time published regularly once a month.

"Table Générale des matières contenues dans le Journal des Sçavans . . . depuis l'année, 1665 . . . jusqu' en 1750 inclusivement . . ." 10 vols., Paris, 1753–1764.

Another edition of vols. 1–105, Amsterdam, 1679–1753, also 1685.

Another edition of the years 1725–1760, Paris, 1725–1760.

"Annales des Sciences . . . faisant suite au Journal des Sçavans," Amsterdam, 1804–1806.

"Journal des Sçavans, combiné avec les Mémoires de Trévoux. Suite des 170 Volumes . . .," Amsterdam, 1756–1757.

"Journal des Sçavans, combiné avec les meilleurs Journaux Anglais," January 1779 to December 1781, Amsterdam, 1779–1781.

Journal des Savants ("British Museum Catalogue of Periodical Publications—Paris," pp. 1370–1371). Edited successively by P. C. F. Danon, le Brun, and others from 1816.

"Table méthodique et analytique des articles . . . 1816–1858," Paris, 1860.

"Table analytique des articles . . . 1859–1908," Paris, 1909.

APPENDIX IV

List of additional works, relating to subjects treated of in this "Bibliographical History," which have not before been especially mentioned herein and which are deemed worthy of perusal:

1486. Reisch (Father Gregory), "Æpitome . . . Marg. Phil. . . . Scibili."
1495. Roberti de Valle Rotho, Magensis . . . "Compendium a Plinio data . . ."
1535. Stœffler (J.), "Cœlestium . . . totius sphericæ . . ."
1536. Mela (Pomponius), "De situ orbis."
1537. Maurius, "Sphera Volgare."
1544. Ulstadius (P.), "Cœlum Philosophorum . . ."
1548. Leonicerus (James), "Compendium de meteoris . . ."
1555. Navagero (A.), "Orationes . . . carmin . . . nonnulla. . . .
1558. Göbel (Severin), "De Succino."
1560. Pedemontani (Alex.), "De Secretis . . ."
1562. Carpentarius (J.), "Descriptionis universæ naturæ."
1571. Titelmanni (Franc.), "Naturalis Philos. Compendium."
1571. Fulco-Fulke, "A goodly gallery . . . Meteors . . ." (also published in 1634 and 1670).
1572. Biringuccio (V.), "Pyrotechnie."
1572. Lemnius (Levinus), "Occulta naturæ miraculæ."
1574. Zacaire (D.), "Livres sur l'arithmétique . . . métaux," etc.
1582. Rao (Cesare), "I Meteori."
1582. Camorano (R.), "Compendio de la arte de navegar . . ."
1586. Malfanti (G.), "Le météore."
1592. Digges (Thomas), "A prognostication . . ."
1596. Gallucci (G. P.), "Ratio fabric andi . . . magnetica acu."
1596. Vuccher (Jean Jacques), "Les secrets et merveilles . . ."
1596. Bodin (J.), "Universæ naturæ theatrum . . ."
1604. Herlicius (D.), "Tractatus de fulmine."
1604. Harward (S.), "Discourse of . . . lightning."
1605. Morales (G. de), "Libro de las virtudes . . ."
1607. Bollenatus Burgundo-gallus, "Theses physicæ . . ."
1609. Goclenius (R.), "Tract. . . . de magnetica curatione." (See also his "Mirabilium naturæ liber," published in 1643.)
1610. Arlensis, "Sympathia septem metallorum . . ."
1610. Argolus (Andreas), "Epistola ad Davidem . . ."
1615. Godigno (N.), "De Abissinorum rebus."
1615. Foscarini (P. A.), "Epistola . . ."
1621. Drebbel (C.), "De natura elementorum."
1621. Tarde (J.), "Les usages . . . esguille aymantée."
1627. Fromondi (L.), "Meteorologicum . . ." (See reference to Fromondi *infra* at 1781 date. He employed heart pulsations to calculate the distance of thunder.)
1630. Longinus (Cæsar), "Trinium magicum . . ."
1631. Kœnio (H.), "Fulminum theoria meteor. . . ."
1632. Remmelinus (Joannes L. U.), "Instrumentum magneticum . . ."

1637. Ward (S.), " Magnetis reductorium . . ." (See also his " Wonders of the loadstone," published in 1640.)
1638. Fludd (Robert), " Philosophia Moysaica . . ."
1641. Fabricius (Hildanus), " Observationum et curationum . . ."
1643. Servius (Petrus), " Dissertatio de Unguento . . ."
1645. Blæu (G. and J.), " Théatre du Monde."
1646. Henricus (Regius), " Fundamenta physices." (See also his " Philosophia naturalis," published in 1654.)
1649. Zucchi (Nicolo), " Nova de machinis philosophia."
1651. Reæl (F.), " Observ. . . . æn de magneetsteen . . ."
1656. Irvine (C.), " Medicina magnetica . . ."
1657. Turner (Robert), " Ars Notaria."
1662. Rattray (Sylvester), " Theatrum sympatheticum . . ."
1662. Westen (Wynant Van), " Het eerste deel . . ."
1663. Helvetius (J. F.), " Theatr. Herculis. . . ." (See also his " Disputatio Philosophica," published in 1677.
1664. Power (Henry), " Experimental Philosophy."
1665. Johnston (J.), " Thaumatographia naturalis."
1666. Accademia del Cimento, " Saggi di naturali esperienze."
1666. " Mémoire d'Homberg, sur l'électr. d'un globe de soufre."
1667. Colepress (Samuel), " Account of some magnetical experiments."
1668. Leotaudus (Vincent), " Magnetologia . . . magnetis philos."
1668. Vitalis (H.), " De magnetica vulnerum curatione."
1673. Mentzel (M. Chn.), " De lapide bononiensi in obscuro lucenti."
1674. Oughtred (W.), " Descript. . . . double horiz. dyal. . . ."
1676. Heidel (W. E.), " Johannis Trithemii . . ."
1677. Dechales (C. F. M.), " Art de naviguer . . ."
1677. Hartmann (Philip Jacob), " Succini Prussici . . ."
1679. Schielen (J. G.), " Bibliotheca enueleata."
1681. Senguerd (W.), " Philosophia naturalis . . ."
1682. Hiller (L. H.), " Mysterium artis. . . ."
1684. Lana-Lanis (Franciscus de), " Magisterii . . . et artis . . ."
1684. Marana (G. P.), " L'espion du Grand Seigneur . . ."
1685. Friderici (J. B.), " Cryptographia . . ."
1686. " Recueil d'expériences sur l'aimant . . ." published anonymously at Lyons.
1687. Dalance (M. D.), " Traité de l'aimant . . ."
1688. Bartholinus (C. T.), " Specimen philos. naturalis . . ."
1688. Boulanger, " Traité de la sphère du monde."
1689. Blagrave (Joseph), " Astrological practice of physick."
1689. Eschenbach (A. C.), " Orphei Argonautica . . ."
1689. Rennefort (Souchu de), " L'aiman mystique."
1691. Cecchi, " Saggi di naturali esperienze."
1692. Brown (R.), " Disputatio philosophica . . ."
1692. Cellio (Marco Antonio), " De terra magnete."
1693. Gregorio (D.), " Lettera intorno all' elettricità."
1695. Hale (Sir M.), " Magnetismus magnus . . ."
1697. Zwinger (Theodor), " Scrutinum magnetis . . ."
1698. Ballard, on the magnetism of Drills in the *Philos. Trans.*, for the year 1698, p. 417.
1698. Tredwey (Robert), in the *Philos. Trans.*, Vol. XIX. p. 711.
1700. Cesi (In.), " De meteoris dissertatio."
1707. " Curiöse speculationes . . . speculirt," Leipzig and Chemnitz.
1714. Billingsley (C.), " Longitude at sea . . ."
1718. Du Petit, Albert, " Secrets Merveilleux . . ."
1718. Luderus (G.), " De methodis . . . declin. . . . magnetis . . ."
1719. Ditton, " Longitude and latitude found by the inclinatory and dipping needle." (See also the edition published in London during 1721.)
1722. Quellmalz (S. J.), " Dissertatio de magnete . . ."
1723. Santanelli (F.), " Philosophiæ reconditæ . . ."
1729. Abercorn (J. Hamilton, Earl of), " Calculations . . . virtue of loadstones."

1729. Wischoff (C.), " De Wonderwerken Godts."
1730. Bailey (Nathan), " Loadstone," in " Dictionarium Britannicum."
1731. Reibelt (J. J. A.), " Thes . . . magnetis mysteriis . . ."
1732. Derham (W.), " Physico-theology."
1734 Marana (G. P.), " Letters writ by a Turkish Spy."
1739. Brémond (François de), in *Philos. Trans.*, Vol. XLI. p. 614.
1740. Mortenson, " Dissertatio de electricitate . . ." Upsal. (Also the 1742 edition.)
1743. Lobe (W.), " De vi corporum electrica."
1744. Akenside (Mark), Book III of " The Pleasures of Imagination."
1745. Piderit (J. R. A.), " Dissertatio inaugaralis . . ."
1745. Psellus (M. C.), " De lapidum virt. Græc. ac Latine."
1745. Rosenberg (A. G.), " Versuche einer Erklarung . . ."
1745. Winkler (J. H.), " Quædam electricitatis . . ." (See *Philos. Trans.* for 1745, p. 307.)
1746. Elvius (Petrus), " Historisk berättelse . . ."
1746. Lohier fils, " Globules lumineux . . ."
1746. Sguario-Squario (Euseb.), " Due Dissertazione . . ."
1746. Trembley (A.), at p. 58, Vol. XLIV of the *Philos. Trans.*
1747. Carli (G.), " Dissertazione . . . bussola nautica . . ."
1747. Faure (G.), " Conghietture fisiche . . . machina elettrica."
1747. Franklin (Georg), " Declaratio phænomenorum . . ."
1747. Gottsched (Johann Christoph), " Nov. Prosp. in hist. electr. . . ."
1747. Maffei (Scipione), " Della formazione de' Fulmini."
1747. Vasquez-y-Morales (D. Jos.), " Ensayo sobre la Electricidad . . ." (This is the translation of Nollet's work, to which is added " Historia de la Elett.")
1748. Collina (Egondio), " Considerazioni . . . bussola nautica . . ." (claims that the compass was in use during the tenth or eleventh century).
1748. Rackstrow (B.), " Miscellaneous Observations . . ."
1748. " Recueil de traités sur l'électricité . . ." (published at Paris).
1749. Belgrado (Giacomo), " I fenomeni elettrici . . ."
1749. Darcet, " Description d'un électromètre."
1749. Mangin, " Question nouvelle . . . sur l'électricité . . ."
1749. Plata (F. M.), " Dissertatio de electricitate . . ."
1750. Krafft (G. W.), " Prælectiones . . . physicam theoreticam."
1750. Secondat de Montesquieu (J. B.), " Histoire de l'électricité."
1751. Berthier, J. E., " Attractions et répulsions électriques."
1751. Binat (Rev. F.), " Electricorum effectuum."
1752. Guérin, " Histoire générale et particulière de l'électricité."
1752. Penrose (F.), " Treatise on electricity," also " Essay on Magnetism."
1753. Rabiqueau (C.), " Le spectacle du feu élémentaire . . ."
1753. Wolf (C.), and Bina (A.), " Physica experimentalis . . ."
1755. Frisi (Paolo), " Nova elect. theoria," also his " De existentia et motu ætheris . . ."
1755. Landriani (G. B.), " Nova electricitatis theoria . . ."
1755. Premoli (C. P.), " Nova electricitatis theoria."
1756. Cartier (J.), " Philosophia electrica ad menten . . ."
1757. Butschany (Matthias), " Dissertatio ex phænom. electricis."
1759. Egeling (J.), " Disq. phys. de electricitate."
1759. Fayol, " Observations sur un effect singulier . . ."
1760. Avelloni (D.), " Lettera . . . al fuoco elettrico . . ."
1760. Dutour (E. P.), " Recherches . . . matière électrique."
1760. Oberst (J.), " Conjecturæ . . . magnetis naturam . . ."
1760. Tillet, " Sur l'incendie."
1761. Laborde (J. B.), " Le clavecin électrique . . ."
1761. Wakeley (Andrew), " The Mariner's compass rectified," as revised by Wm. Mountaine.
1762. Paulian (A. H.), " Conjectures nouvelles . . ." likewise " Nouvelles conjectures sur les causes des phénomènes électriques," published at Nîmes. (See also his "Electricité soumise . . ." Avignon, 1768.)
1764. Meyer (Johann Friedr.), " Chymische versuche . . ."

1765. Schmidt (N. E. A.), "Vom magnete," published at Hanover.
1767. Cellesius (Fabricius), "De naturali electricitate . . ." A very rare work published at Lucca.
1769. Krunitz (Johann Georg), "Verzeichnis der vornehmsten schriften vonder Electricitat . . ." published at Leipzig.
1771. Barletti (Carlo), "Nuove sperienze elettriche . . ."
1771. Berdoe (M.), "Inquiry into the influence of the electric fluid in the structure and formation of animated beings." This curious work was published at Bath, where Mr. Berdoe's book "On the electric Fluid" was also published in 1773.
1772. Herbert (J. Edler von), "Theoriæ phænomenorum . . ." also "Dissertatio . . . aquæ . . ." published at Labacii during the same year.
1772. Para, "Cours complet. . . ." also "Théorie . . ." published in 1786.
1773. "Essay on electricity . . . late discoveries of Jas. Dævin, C. M. F., Bristol."
1774. Fontana (Felice), "Descrizioni ed usi . . . dell' Aria."
1774. Pasumot (Fra.), "Observations sur les effets de la foudre . . ."
1775. Detienne, "Peculiar construction of conductor of electrical machine for increasing the action thereof."
1775. Jacquet de Malzet (Louis Sebastien), "Lettre . . . sur l'électrophore."
1775. Simmons (John), "An essay on the cause of lightning."
1776. Changeux (P. N.), "Météorographie, ou l'art d'observer les phénomènes de l'atmosphère," published at Paris.
1776. Landriani (Marsiglio), "Osservazioni sulla poca . . ."
1776. Rossler (T. F.), "Progr. de luce primigenia." He says that the light before the creation of the sun, mentioned by Moses, was an electrical light. See besides "Le soleil est un aimant," by R. P. Secchi ("*Le Cosmos*," 453, Paris, 1854).
1776. Schinz (Salomon), "Specimen phys. . . ." also "Supplementum speciminis physici de Electricitate," published at Turici in 1777.
1777. Chigi (Aleso.), "Dell' Elettricità terrestre-atmosferica dissertazione" (*Bibl. Ital. di El. e Magn.*, p. 30).
1777. Gross (Johann Friedr.), "Précis des poses électriques."
1777. Vairano (Josephus), "Diatriba de Electricitate."
1777. Weigel (Chr. Ehrenfried), "Grundriss der reinen v. angewandt. Chemie."
1778. Chaptal (J. A. C.), "Observations sur l'influence de l'air . . ." (published in the Reports of the Toulouse Academy, first series).
1778. Steavenson (Robert), "Dissert. de electricitate. . . ."
1779. Lüdicke (A. F.), "Comment. de attract. magnetum . . ."
1780. Hemmer (Johann Jacob), Articles in the Commentat. Acad. Theodoro-Palatine published at Mannheim.
1780. Pilatre des Rozier in the *Journal de Physique*, Vols. XVI and XVII.
1780. Tozzetti (Targioni), "Atti e memorie inedite . . ."
1781 Bianchi (Iso), his "Elogium on Libertus Fromondi," published at Cremona.
1781. Brisson, "Dictionnaire de Physique."
1781. Gabler (Matthias), "Theoria Magnetis."
1781. Lacépède, "Essai sur l'électricité naturelle et artificielle."
1782. *Le Mercure de France*, No. 23, for June 1782.
1782. Sans (M. de), in the *Journal de Médecine* for this year.
1783. Milner (Thomas), "Exper. and Observ. in Electricity."
1785. Bruno (M. de), "Recherches . . . fluide magnétique."
1787. Crell (L. F. F.), the miscellaneous scientific articles in his *Chemische Annalen*, published at Helmstadt.
1787. Hoffmann (C. L.), *Magnetist*, published at Frankfort.
1789. Pasqual (A. R.), "Descrub. . . . aguja nautica . . ."
1790. Frémery (N. C. de), "Dissertatio . . . de fulmine."
1790. Segnitz (F. L.), "Specimen . . . elect. animali . . ."
1791. Peart (Edward), "On electricity . . . Magn. . . . and El. Atmospheres," published at Gainsboro'.
1792. Aberg (V. J.), ". . . vim magneticam et electricam."

1792. Carminati (Bassiano), in Brugnatelli's *Giorn. Fis. Med.*, II. p. 115.
1792. Reil (J. C.), " Uber thierische elektricität."
1793. Creve (J. C. I. A.), " Beiträge zu Galvanism . . ." published at Leipzig and at Frankfort. (See his " Phénomènes du galvanisme " in the *Mém. de la Société méd. d'émulation.*)
1793. Hauch (Adam Wilhelm von), his articles in the *Vidensk. Selsk. Skrift. Ny Samml*, published at Copenhagen.
1794. Gutle (J. C.), " Zaubermechanik od. Beschreibung . . ." published at Nürnberg.
1794. Hopf (C. G.), respond E. Eschenmayer, " Dissert. sistens . . . theoriæ " (Sue, Vol. I. p. 133).
1797. Bressy (Jos.), " Essai sur l'électricité de l'eau."
1798. Hoffmann (J. C.), " Anweisung gute Elektrisirmaschinen . . ." published at Leipzig.
1798. Tingry (P. F.), two articles, " Sur la phosphorescence des corps " and " Sur la nature du fluide électrique," published in the *Journal de Physique*, Vol. XLVII.
1798. Walker (Ralph), " A treatise on the magnet . . ."
1799. Arnim (L. A. von), " Versuch einer theorie . . ." published at Halle.
1799. " Proceedings of the Am. Phil. Soc.," Old Series, Vol. IV. p. 162, for " An Essay tending to improve intelligible signals . . ."
1800. Hulme (N.), see his " Experiments and Observations . . ." in the *Philos. Trans.* for 1800, Part I. p. 161, as well as Vol. IV of Reuss's *Repertorium.*
1800. Treviranus (Gottfried R.), see articles in *Gilb. Annal.*, Vol. VII as well as in Vol. VIII.

APPENDIX V

MERCATOR'S PROJECTION

THE JUST CLAIM OF THE ENGLISH MATHEMATICIAN, EDWARD WRIGHT

MERCATOR, GERARDUS (latinized form of Gerhard Kremer), 1512–1594, a Flemish geographer and mathematician, who is mentioned at pp. 79, 508, 516 of this "Bibliographical History of Electricity and Magnetism," is reported to have invented a new method of making maps. The name of Mercator, it is said, was given to Kremer on account of the great usefulness of his reported invention to mercators or merchants.

Mercator's earliest map was published in 1537. One year later appeared his Map of the World (rediscovered during 1878 in New York), and, in 1541, he introduced a terrestrial globe which was followed, ten years afterwards, by his equally well-known celestial globe. Then appeared, in 1568–1569, the first edition of his celebrated planisphere, intended for use in navigation, which is the earliest known map on what is called "Mercator's Projection," and, in later years, he brought out many other maps as well as geographical tables, etc., which are too numerous to be specified here. [See article *Mercator* in the Belgian "Biographie Nationale," Vol. XIV, 1897, and consult likewise "L'œuvre géographique de Mercator" by Van Ostroy, "Meyers Konversations Lexikon," 1897, Vol. XII, pp. 153–154, also "La Nouvelle Biographie Générale" de Mr. le Dr. Hoefer, Vol. XXV. p. 11.]

The original constructor of the chart known as "Mercator's Projection" is, however, said to be a very able English mathematician, Edward Wright (1560–1615) who is alluded to herein at pp. 78, 79, 520, 524, 532. He was the designer of a very large sphere for Prince Henry, which showed the motion of the planets, etc., and he predicted the eclipses for a period of 17,100 years.

So much has been said herein regarding different well-known maps that the following cannot but prove interesting. It is in apparently just claim on behalf of Edward Wright to the abovenamed invention, and, as stated in the volume published during

1880 by John Davis for the Hakluyt Society, the first Map of the World that was engraved in England on Wright's (Mercator's) projection is fully described by Mr. C. M. Coote in a Note at pp. 85–95 of the Davis "Voyages and Works." That map, he says, was published one year after Wright had explained the principle of the projection in his "Certain Errors." From Mr. Coote's description, the following is extracted :

What appears to have escaped the notice of Hallam, and those who have attempted to describe it at various times down to our day, is, that our map is laid down upon the projection commonly known as Mercator's. So little appears to be known as to the early history of this projection, that as recently as April 16, 1878, it has been suggested by Mr. Elias F. Hall that charts upon this projection were not in general use among seamen at a period much earlier than 1630. Still more recently it has been gravely asserted that a distinguished Admiral of the American navy only knew of it as the Merchant's projection, and that he never knew that there was such a man as Mercator. In 1569 was produced at Duisbourg, Mercator's well-known *Mappemonde,* and many years elapsed before it attracted the notice of other mapmakers. However interesting it may be to us as a monument of geography, it is now admitted that, as regards the projection, it is only approximately correct up to latitude 40. For the want of a demonstration of the true principles upon which such a projection was to be laid down, beyond the legend on the *Mappemonde,* it found but few imitators. The only three known to us are Bernardus Puteanus of Bruges in 1579, Cornelius de Jode in 1589, and Petrus Plancius in 1594. Of the first and third no examples of their maps on this projection are known to exist, these two doubtless had all the imperfections of the original Mercator. De Jode's "Speculum Orbis Terrarum" of 1589 is remarkable, as, while being on the old plane projection with the lines of latitude and longitude equidistant, there is to be seen on it a feeble attempt to divide the central meridional line according to the idea of Mercator, one of the best possible proofs how imperfectly this idea was understood by Mercator's own fellow-countrymen. About 1597 was published by Jodocus Hondius in Amsterdam, a map entitled Typus Totius Orbis Terrarum, etc., easily to be recognized by an allegorical figure, at the bottom of it, of a Christian soldier armed for the fight against all the powers of evil. This is on the true projection, known as Mercator's, but which is really that of Edward Wright. From Hondius' connection with Mercator, and whose joint portraits from the frontispiece of the well-known Atlas of the latter, it might with good reason be supposed that Hondius acquired the art of projecting this map from Mercator, yet if one thing is more certain than

another in the history of this projection, it is the fact that Hondius did not acquire this art from Mercator or his map, but from Edward Wright, the friend and colleague of Hakluyt.

In proof of this, the following evidence is adduced. We learn from Blundeville that, at some previous period, probably as early as 1592, Wright sent his friend, the author, "a table to drawe thereby the parallells in the Mariner's Carde, together with the vse thereof in trewer sort, with a draught" or diagram of the projection. These, it is evident, were extracts from Wright's "Errors in Navigation," then in MS. Wright, in his preface to the reader, in his work when printed, bitterly complains that he was induced to lend MS. to Hondius, who, with its aid and without Wright's consent, prepared and published several "mappes of the World, which maps had been vnhatched, had not he [Hondius] learned the right way to lay the groundwork of some of them out of his book." That the above Typus is one of the printed maps complained of, seems to be proved by the allusion to Wright to be found on it.

The strongest evidence against the theory of Hondius having acquired this art from Mercator, is the fact that in none of the subsequent editions of Mercator's Atlases edited by him is there a map on this projection to be found. The truth is, that to Wright, and not to Mercator, is due the honour of being the first to demonstrate the true principles upon which such maps were to be laid down by means of the now well-known Tables of meridional parts.

The first legitimate attempt to lay down a map upon the really true projection, is no other than the original of our map. Before proceeding to point out some of its remaining points of interest, it will be convenient here to endeavour to remove one or two misapprehensions respecting it, which are even now entertained by more than one of our eminent booksellers.

Mr. Quaritch, without adducing the least amount of evidence, asserts that "Hakluyt intended to insert this map in his work of 1589." This is impossible, as from internal evidence it could not possibly have been produced at an earlier period than 1598 or 1599, as has been before pointed out. Upon this point we fear that Mr. Quaritch has allowed himself to be misled by the pardonable blunder of Hallam. Again he says, that Hakluyt calls the original of our great map a terrestrial globe. This is also a mistake. When Hakluyt said a globe, he meant one, and not a map; such a globe as he describes was forthcoming in 1592, at a period midway between the first edition of the "Voyages" and the appearance of our map. The only example of this globe at present known to exist is preserved in the Library of the Middle Temple.

Hitherto one of the difficulties in describing and establishing

the identity of this map has been its anonymous authorship. Mr. Quaritch, in an otherwise fair appreciation of the writer's labours in this direction, has thought fit, in another part of his catalogue, to charge the writer with appropriating Mr. Quaritch's labours in this matter of authorship. The charge has found no foundation in any fact whatsoever. The writer's conclusions about it were based solely upon a comparison made between our map and a globe, two things which Mr. Quaritch has confounded. The globe referred to is known to be by Molyneux, the reference to it in the title of the map led the writer to the not unnatural inference that they were by one and the same author. This position the writer strengthened by two quotations from a scarce tract by the late Dr. J. G. Kohl of Bremen, which was published twenty years before Mr. Quaritch's catalogue of 1877 [No. 11919] saw the light. The conclusion arrived at by the writer, without any assistance from Quaritch, was that our map, circa 1600, was a new one, on a new projection, made by one of the most eminent globe-makers of his time, probably under the superintendence of Hakluyt. The evidence upon this point is of course strongly circumstantial only, which future research may either refute or confirm. Be this as it may, one thing is now quite certain, namely, that our map, to a very great extent, bears evidence upon the face of it of the handiwork of another of Hakluyt's friends and colleagues, hitherto unsuspected, we take it, even by Mr. Quaritch. Allusion has been already made to Wright's "Errors in Navigation," the first edition of which was published in 1599. In 1610 appeared the second edition, in which mention is made of a general map, which map it has not been our good fortune to see, as the copy in our national library is without it. Several editions were subsequently published by Moxon. In these are to be seen copies of a map laid down upon lines almost identical with ours. They have geographical additions up to date, and also indicate the variations of the compass. These later maps are avowedly ascribed to Wright, and a comparison of any one of them with our map most certainly points to one common source, namely, the original. The conclusion is therefore irresistible, that whatever may be due to Molineux or Hakluyt in the execution of the original, it also represents the first map upon the true projection by Edward Wright. It will be observed as a somewhat happy coincidence that Hallam's almost first words of introduction to our map are a reference to the Arctic work of Davis, 1585–1587. On the map is also to be observed a record of the discovery by the Dutchman Barents, of northern Novaya Zemlya, in his third voyage in 1596. This is the latest geographical discovery recorded upon it, which serves not only to determine the date of the map, but to establish for it the undoubted claim of being the earliest one engraved

in England, whereon this last important Arctic discovery is to be found. The striking similarity between our map and Molineux's globe, in the delineations of these Arctic discoveries of Davis and Barents, seems to point to the conclusion that, so far as the geography is concerned, they both came from one source, namely, the hands of Molyneux.

Arctic discovery did not escape the notice of our immortal Shakespere. In some fifty lines preceding his supposed reference to our map in "Twelfth Night," occur the following words. "You are now sailed into the north of my lady's opinion, where you will hang like an icicle on a Dutchman's beard." The antithetical idea being of course the equatorial region of the lady's opinion. If the date assigned to it is correct it is probable in the extreme that the thought underlying these words was suggested to the mind of Shakespere by a glance at the upper portion of our map, evidently well known in his time as a separate publication. The remaining points that call for notice are as follows. The improved geography of the whole of the eastern portion of our map, as compared with its contemporaries, and the traces of the first appearance of the Dutch under Davis and Houtman at Bantam. On all the maps was to be seen the huge Terra Australis of the old geography. This, as Hallam remarked, had been left out on our map; but what is so remarkable is that upon it is to be observed, rising "like a little cloud out of the seas, like a man's hand," the then unknown continent of Australia. It will be observed that Hallam describes the original as "the best map of the sixteenth century." Mr. Quaritch improves upon this, and says it is "by far the finest chartographical labour which appeared, from the epoch of the discovery of America down to the time of d'Anville." If this implies a reference to our map as a work of art, *i. e.* an engraving, we beg to differ from him, as such terms are misleading. As a specimen of map engraving, it will not compare with even its pirated prototype by Hondius. The art of engraving by Englishmen, more particularly that of maps, was at this period, as is well known, in its infancy. Maps and illustrations for books were for the most part executed abroad, and those who did work here were almost all foreigners. The two best known were Augustus Ryther, who executed among other things the maps for Saxton's Atlas, and Hondius, who did those for Speed's Atlas. Mr. Richard Fisher writes: "We have scarcely any record of any Englishmen practising engraving in this country prior to the commencement of the seventeenth century." The names, however, of two are afforded us by Davis himself in his Introduction to the "Seaman's Secrets," namely, those of Molyneux and Hillyer. It is to be hoped that the position of our map in the history of cartography is secured upon

firmer grounds than those suggested by the best intentions of Mr. Quaritch. It was the writer's belief in this that first led him to express the hope that the original of the facsimile, so admirably done for the Society, would henceforth be as firmly associated with Shakespere's "Twelfth Night" as it certainly is now, not only with the page of Hakluyt, but with the publications of the Society that bears his name.

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(*Embracing much additional data.*—See *Preface*)

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